Indigenous Technical Knowledge of

Indian Marine Fishermen

with reference to Climate Change

A Corollary of National Initiative On Climate Resilient Agriculture

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Indigenous Technical Knowledge (ITKs') of
Indian Marine Fishermen with reference to Climate Change

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PREFACE

For fishermen, the knowledge about sea is vital for their survival. Over the years, fishermen have accumulated vast knowledge about the sea and most of them consider the Sea as the "Mother" or "Goddess" replete with feelings and expressions. Many of the expressions are related to some reasons and this information is being passed on from one generation to another. Most of the ITKs' are climate related, like indications of storm, indications of tsunami, indications of good catch and less catch etc., These insights and adaptive skills of fisher folk are often derived from many years of experience and may be called cultural traditions which have co-evolved with the local environments. These information often have been communicated and learned through family members over generations. Such knowledge systems may pertain to various cultural norms, social roles, or physical conditions such as the climate or lunar cycles. Obviously, decisions to use these ideas are not based on empirical measurements or cost-benefit analyses, as in conventional modern science. In some cases, the knowledge is based on unique epistemologies, philosophies, intuitions, and principles, which differ from modern scientific tenets.

At CMFRI, under the project National Initiative on Climate Resilient Agriculture (NICRA), collection of Indigenous Technical Know-how was carried out on an all India basis, from all the maritime States. A write shop, the first of its kind, was organised at the Mangalore Research Centre of CMFRI, for discussing the ITKs' collected from various States and also to discuss the scientific truth underlying these beliefs.

The write shop was the first step towards incorporating, validating, pretesting the ITKs' collected by the scientists in the project with respect to climate change, in the respective State's before evolving in to a book form. The Scientists, technical staff, scholars, artists and fishermen, from eight maritime states presented their ITKs' collected at this forum. As many as 200 ITKs' were presented and discussed upon. Out of these, ITKs' those which were found to be more common and scientifically valid were included in the book. This publication is based on the outcome of the discussions and findings from the write shop, which give an overview of ITKs' prevailing in marine fisheries, with special reference to climate change. This compilation will provide the state-of-the art overview of best practices and experiences which can be blended with the modern scientific knowledge, to benefit all the stakeholders involved in marine fisheries.

Many a literature speaks of the traditional knowledge among fisher folk, but there is a dearth of systematic documentation of the existing ITKs' in a scientific ensemble. Documentation of the valuable ITKs' with respect to climate change have been undertaken at the field level in the respective states of Gujarat, Maharashtra, Karnataka and Kerala along the west coast and West Bengal, Odisha, Andhra Pradesh and Tamilnadu along the east coast of India. The book represents an important contribution towards achieving the goal of establishing international responsibility for the ethical collection, preservation, dissemination and application of fishers knowledge, for the benefit of human kind. I compliment the team lead led by Dr. P.U. Zacharia and Dr. P.S. Swathi lekshmi for bringing out this compilation.

15-06-2013
Kochi

Dr. G. Syda Rao
Director

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1 Introduction and Methodology

When the wind is blowing in the North
No fisherman should set forth,
When the wind is blowing in the East,
'Tis not fit for man nor beast,
When the wind is blowing in the South
It brings the food over the fish's mouth,
When the wind is blowing in the West,
That is when the fishing's best!

- Ancient proverb

The fisher folk of coastal India possess a rich repertoire of ancient knowledge and traditional wisdom with respect to various climate change related phenomena which they have made use of in their day to day fishing activities. This provides them, the rule of the thumb to be followed with respect to observed indicators or relationship with in events of climate change related inflections. These local fisher communities over centuries, have developed and implemented extensive mitigation and adaptation strategies that have enabled them reduce their vulnerability to past climate variability and change. However, the fact that this rich treasure house of indigenous wisdom which serves as a complement to modern scientific methods of adapting and mitigating the adverse impacts of climate change in fisheries has been largely ignored or rather receded into the mists of antiquity.

Incorporating indigenous knowledge into climate change policies can lead to the development of effective mitigation and adaptation strategies that are cost-effective, participatory, and sustainable (Robinson and Herbert 2001; Hunn, 1993).

The tremendous increase in the worlds' population which has exceeded 7 billion in 2011, according to United Nations estimate is a major cause of concern due to the

indiscriminate dependence on fossil fuel based modes of production which has led to the increase in the concentration of green house gases in the atmosphere.

Climate change in the fisheries sector is characterized by increase in the global temperature, changing rainfall pattern, wind speed, sea level rise and other parameters seriously impacting human lives.

Although indigenous peoples' "low-carbon" traditional ways of life have contributed little to climate change, indigenous people are the most adversely affected by it. This is largely a result of their historic dependence on local biological diversity, ecosystem services and cultural landscapes as a source of sustenance and well-being.

The very identity of indigenous peoples is inextricably linked with their lands, which are located predominantly at the social-ecological margins of human habitation — such as small islands, tropical forests, high-altitude zones, coasts, desert margins and the circumpolar Arctic. Here at these margins, the consequences of climate change include effects on agriculture, pastoralism, fishing, hunting and gathering and other subsistence activities, including access to water.

Though, indigenous peoples, comprise only four per cent of the world's population (between 250 to 300 million people), they utilize 22 per cent of the world's land surface. In doing so, they maintain 80 per cent of the planet's biodiversity in, or adjacent to, 85 per cent of the world's protected areas. (Raygorodetsky, 2011)

With collective knowledge of the land, sky and sea, these people are excellent observers and interpreters of change in the environment. The ensuing community-based and collectively-held knowledge offers valuable insights, complementing scientific data with chronological and landscape-specific precision and detail that is critical for verifying climate models and evaluating climate change scenarios developed by scientists at much broader spatial and temporal scale. Moreover, indigenous knowledge provides a crucial foundation for community-based adaptation and mitigation actions that sustain resilience of social-ecological systems at the inter-connected local, regional and global scales.

While unmitigated climate change poses a growing threat to the survival of indigenous peoples, more often than not they continue to be excluded from the global processes of decision and policy making, such as official UN climate negotiations, that are defining their future. The coastal fisher folk who are some of the marginalized sections of the population when it comes to instances of their involvement and participation in climate change mitigation programmes and strategies. They offer a treasure trove of knowledge which would become phased out and lost forever if they are not properly documented and validated.

Importance of Indigenous Technical Knowledge in Climate Change:

Indigenous knowledge, although new to climate science, has been long recognized as a key source of information and insight into domains such as agroforestry,

traditional medicine, biodiversity conservation, customary resource management, impact assessment, and natural disaster preparedness and response. Indigenous people and rural populations are keen observers of their natural environment.

- Indigenous observations and interpretations of meteorological phenomena are at a micro level, have considerable temporal depth and highlight elements that may be marginal or even new to scientists. They focus on elements of significance for local livelihoods, security and well-being, and are thus essential for adaptation.

- Indigenous peoples' observations contribute importantly to advancing climate science, by ensuring that, assessments of climate change impacts and policies for climate change adaptation are meaningful and applicable at the local level.

- Indigenous responses to climate variation typically involve changes in livelihood practices and other socio-economic adjustments. Strategies such as engaging in multiple livelihood activities and maintaining a diversity of plant varieties and animal races provide a low-risk buffer in uncertain weather environments. The ability to access multiple resources and rely on different modalities of land use contributes to their capacities to manage for local-level climate change.

- Traditional systems of governance and social networks improve the ability to collectively manage diversity and share resources, while dissipating shocks and reinforcing innovative capacities.

Concept of Indigenous Technical Knowledge (ITK)

Indigenous Technical Knowledge (ITK) is the local knowledge – knowledge that is unique to a given culture or society. It contrasts with the international knowledge system generated by universities, fisheries, animal husbandry research institutions and private firms. It is the basis for local–level decision making in agriculture, health care, food preparation, education, natural resource management and a host of other activities in rural communities (Warren 1991). ITK is the information base for a society, which facilitate communication and decision making. Indigenous information systems are dynamic, and are continually influenced by internal creativity and experimentation as well as by contact with external systems.

Indigenous Technical Knowledge (ITK) with respect to climate change in fisheries can be operationalized as the knowledge/cognitive capital of the fisher folk with respect to prediction/forecasting of various weather parameters and prediction of different types of fish availability and their catch based on their mental models with respect to various perceived changes in the weather parameters.

As a summary of various definitions, the term indigenous technical knowledge may be denoted mainly as a tacit type of knowledge that has evolved within the local (grass roots) community and has been passed on from one generation to another and encompasses not only local or

indigenous knowledge, but also scientific and other knowledge gained from outsiders.

Indigenous Knowledge (IK): is the participant's knowledge of their temporal and social space. Indigenous knowledge as such refers not only to knowledge of indigenous peoples, but to that of any other defined community.

Indigenous Knowledge System (IKS): delineates a cognitive structure in which theories and perceptions of nature and culture are conceptualized. Thus it includes definitions, classifications and concepts of the physical, natural, social, economic and ideational environments. The dynamics of the IKS takes place on two different levels, the cognitive and the empirical. On the empirical level, IKS are visible in institutions, artefacts and allied technologies.

Indigenous Technical Knowledge (ITK): is specifically concerned with actual application of the thinking of the local people in various operations of agriculture and allied areas.

Belief: change in behavior of insects, animals and vegetation indicating a forthcoming event without any scientific rational but be true in happening.

Innovation: outside the area of ITK, but scientifically based development of practices using the locally available resources to solve specific problems.

In the emerging global knowledge economy a country's ability to build and mobilize knowledge capital, is equally essential for sustainable development as the availability of physical and financial capital. The basic component of any country's knowledge system is its indigenous technical knowledge. It encompasses the skills, experiences and insights of people, applied to maintain or improve their livelihood. ITK is developed and adapted continuously to gradually changing environments and passed from generation to generation and closely interwoven with people's cultural values. ITK is also the social capital of the poor, their main asset to invest in the struggle for survival, to produce food, to provide for shelter or to achieve control of their own lives.

The marine fisheries scenario in India presents a picture of heterogeneity sacrosanct with a population of four million marine fisher folk, residing in 3, 288 marine fishing villages in 9 maritime States and 2 Union territories (**Marine Fisheries Census, CMFRI, 2010**) ceremoniously contributing to the country's total marine fisheries production of 3.32 mt. (Sathiadhas et.al, 2012), accounting for a foreign exchange earnings of Rs. 10,000 crores. (2009-2010)

In the emerging global knowledge economy a country's ability to build and mobilize knowledge capital, is equally essential for sustainable development as the availability of physical and financial capital. The basic component of any country's knowledge system is its indigenous technical knowledge. It encompasses the skills, experiences and insights of people, applied to maintain or improve their livelihood. ITK is developed and adapted continuously to

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INFORMAL RESEARCH TOOLS FOR INVESTIGATING ITK

Semi-structured interviews: Semi-structured interviews allow the participants more scope to investigate what people know and to follow up topics of interest as they arise in the discussion. They can be used with groups and individuals.

Group (focus) interviews: Group interviews provide exchanges between participants with differences of opinion which can often lead to greater insights into people's perceptions. Care is required over the composition of the group so that as many participants as possible feel free to express their opinions, especially those with less status who may be better interviewed in a separate group or individually.

Key informant interviews: 'Experts' – those identified by local people as having specialist knowledge – may be interviewed taking care that they do not only include those with formal education and access to scientific knowledge.

Field visits and transects: These combine observation and discussion and are useful in allowing the farmer or respondent to point things out in situ. They may also provide a more relaxed atmosphere than a group meeting, making communication easier.

Field observations These are useful for comparison of actual practice to the 'norms' presented in group discussions or interviews.

Mapping, diagramming, ranking exercises and games: These can be used to elicit farmers' perceptions, including spatial conceptions, definitions, classifications and boundaries. Tools include participatory mapping, ranking of importance, comparing characteristics using pair wise ranking, diagrams, seasonal calendars and network diagramming.

Local classification systems/taxonomies: This is quite a difficult area, involving the identification of local terms, then asking local people to sort and group the categories, identifying common features and contrasts in the context of the wider language and cultural system.

Cultural expression: The content of songs, poetry and speeches on celebrations and public occasions can reflect significant messages and social values. Surveys which relate the respondents' knowledge and attitude to their resulting practices are often known as knowledge, attitude and practice (KAP) surveys.

Structured questionnaires and knowledge tests

Structured questionnaires and knowledge tests have,

conventionally, been used by agricultural extension researchers and others to find out about how much local people know. However, such a quantitative approach is not usually a good starting point for studies of KAP, unless the researcher already has an in-depth knowledge of local perceptions and practices. Imposing the rigid structure of a questionnaire implies that the researcher already knows enough about people's perceptions and practices to be able to write specific, unambiguous and comprehensible questions. In practice, these questionnaires may reveal whether the respondents understand scientific terms but provide little information on what the respondents' own ideas might be. Often the results are scored like a knowledge test. If a respondent's answer differs from scientific knowledge or recommended practice it may be classed as 'wrong' and he or she may be considered as having no knowledge. However, structured surveys can have a useful role in following up and verifying hypotheses generated using rural appraisal and other qualitative methods. For example, if it has been found from group interviews that farmers think that certain weeds are good indicators of soil fertility, then a carefully worded questionnaire can be used to determine how widespread this knowledge is.

Methodology:

Under the National Initiative on Climate Change (NICRA) Project, it was decided to document the Indigenous Technical Knowledge with respect to climate change. A number of Indigenous Technical Knowledge has been collected in marine fisheries, but none so far has been collected in the realm of Climate Change. The study was conducted from April 2011 to March, 2012 in the eight coastal States of Gujarat, Maharashtra, Karnataka and Kerala along the west coast and West Bengal, Odisha, Andhra Pradesh, Tamil Nadu along the east coast. A well-structured interview schedule was used for documentation of the ITKs. Participatory Rural Appraisal methods such as Participatory diagramming, Participatory transects, Rapid Rural Appraisal techniques, use of Key informants and focused group discussions and interactions were used for the study.

After the documentation of the ITKs at the field level, it was decided to conduct a write shop by inviting scientists, who were involved in the data collection from the eight coastal states, fisher folk from whom the ITKs were documented, fishermen representatives and local leaders. The write shop was conducted at the Mangalore Research Centre of CMFRI from 22-03-2012 to 24-03-2012. The main aim of the write shop was to bring out a publication in a very short time simultaneously ensuring that every possible information collected was verified by the scientists and end users, discussed at length and classified as an ITK, based on scientific rationale, belief which defies scientific explanation but found/observed to truly occur under field conditions and agreed upon and endorsed by a larger populace.

2 Write Shop on **Indigenous Technical Knowledge (ITK)** of Fisher folk on Climate Change

Tools for Knowledge and Learning

A Write shop is a very intensive process aimed at bringing together a range of relevant stakeholders – along with desktop publishing specialists – to produce a publication in a very short time. Write shops are an excellent way of bringing together different groups (scientists, extension personnel, NGO staff, policy makers, farmers) with different perspectives on the subject. Written materials can be produced in a very short time by people who do not have the time to write extensively. With suitable preparation, it is possible to produce material ready for the printer within a few days of the end of the Write shop itself. The process enables comments and revisions from other participants (analogous to the peer review in conferences). Write shops are not useful for lengthy literature reviews or for the presentation of detailed information. The subject area must be divided into topics and assigned to individual participants. Several authors can contribute to each section of the material.

Detailed Outline of Process

Preparation

Before the Write shop, a steering committee lists potential topics and invites resource persons to develop first drafts on each topic, using guidelines provided. These participants bring the drafts and various reference materials with them to the Write shop.

Draft

During the Write shop itself, each participant presents their draft paper, using overhead transparencies of each page. Copies of each draft are also given to all the other participants, who critique the draft and suggest revisions. After the presentation, an editor helps the author revise the draft. An artist can draw illustrations to accompany the text. The edited draft and artwork are then desktop-published to produce a second draft. Meanwhile, other participants also present papers they have prepared. Each, in turn, works with the team of editors and artists to revise and illustrate the materials.

Thus, a write shop is a participatory way of packaging knowledge over a short period of time

The Write Shop Process

Aim: To develop materials, revise, put them in to final form, and take full advantage of various participants across regions.

- Incorporation of inputs from participants of diverse experience and expertise
- Allows validation of ideas by range of experts
- Concentration of resource persons, editors and artists at one time and place leading to publications

Thus, a write shop is a participatory way of packaging knowledge over a short period of time

Objectives

General: To produce comprehensive information material in the form of a book .

Specific:

- Identification & Capture of ITKs' from different States of the Country
- Documentation of Case studies
- To develop writing, editing skills
- Strengthen linkage between partners

The standard model

Before write shop

- Identify audience and objectives
- Identify type of materials needed
- Identify theme of book, break it into separate "topics"
- Prepare guidelines for authors, invite authors to write drafts

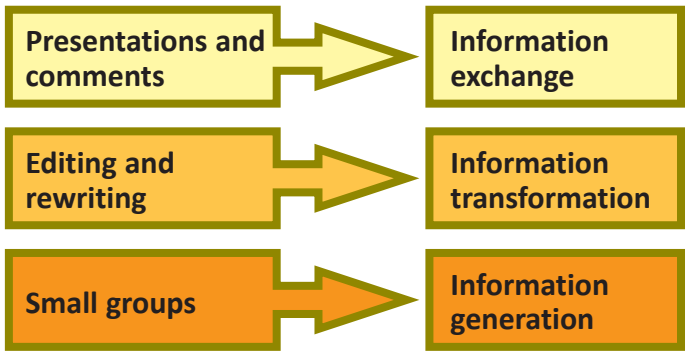
During write shop

- Introduce write shop procedure
- Each author presents draft
- Audience comments
- Author and editor take notes
- Editor and author revise manuscript
- Artist draws illustrations
- Author presents draft 2
- Small groups develop ideas

After write shop

- Editor revises manuscripts and checks final queries
- Final draft laid out, proof read, printed and distributed

Three processes in write shop



Presentations and comments

- Like academic peer review
- Validate information, expand on it based on own knowledge
- Horizontal communication or information exchange

Editing and rewriting

- Critical, detailed look at draft
- Convert into forms suitable for audience
- Simplification (or elaboration) Information transformation
- Small Group Discussion
- Small groups

Types of products

- Information kits
- Source books
- How-to manuals
- Extension materials
- Case-based texts
- Policy briefs
- Training curricula and materials
- Conference papers, scientific articles
- Project design documents
- Project evaluation documents

- Video and audio scripts
- Textbooks
- Websites

Write shop on ITKs'' from marine fisheries with respect to Climate Change

During the write shop held at the Mangalore Research Centre of CMFRI from 22-03-2012 to 24-03-2012, a heterogeneous group consisting of 30 scientists, 60 fisher folk and 2 artists participated in the deliberations. The ITKs' were presented by the scientists/technical officers who documented them from the respective States and were presented before the audience. Fisher folk and scientists were called upon to validate the ITKs' and the scientists gave the scientific rationale as they were presented state wise. It was observed during the course of the interaction that, birds, animals which were harbingers of climate change related phenomena and their study of peculiar behaviours during such times defied scientific explanation but, nevertheless were found to be true in the field situations as agreed upon by majority of the fisher folk. These too were classified as ITKs' based on traditional wisdom passed over generations to posterity.

The following methodology developed at the Summer school on Gender Mainstreaming for Resilient Agriculture held at the Project Directorate for Women in Agriculture during July 11-August 7th , 2012 was used for validation of the ITKs' collected from all the States.

Methodology for Validation of ITKs':

1. Documenting the ITKs' from different sources.

2. Presentation before the scientists, fishermen (preferably aged, traditional and experienced) in a scientific fora/ write shop for establishing its rationality.

3. Classifying the ITKs' based on its domain. (eg ITKs' based on climate change, ITKs' based on capture fisheries, culture fisheries etc.

4. Assigning the most significant ITKs' to expert groups (consisting of scientist groups and farmers groups for establishing the rationality.

5. The ITKs' which were validated by expert groups were authenticated and selected for publishing.

The following pages give a pictorial depiction of the ITKs' documented from the eight coastal states of India.

Scientist interacting with fishermen in the field, Udupi district, Karnataka

Video graphing of the Write shop process

Participatory diagramming in progress

Pictorial depiction of ITKs''

Inaugural session of the Write shop

Stakeholders at the Write Shop

3 ITKs' of **Karnataka**

Karnataka state, in southwest India, has a coastline of 300 km and consists of three coastal districts namely, Dakshina Kannada, Udupi and Uttar Kannada. There are 144 marine fishing villages and 96 marine fish landing centres in Karnataka. There are 30,713 marine fishermen families in the state with a population of 1,67,429. Among 30,713 fishermen families, 93% are traditional fishermen. There are 14,023 crafts in the fishery of which 3,643 are mechanized, 7,518 motorized and non-motorized formed the rest.

The following Indigenous Technical Knowledge (ITK) were reported from Karnataka.

- During new moon fish availability is more.
- When wind blows from west side to shore, fish availability is more.
- Winds blowing from south to north coupled with appearance of white sea gull is indicative of rough seas and impending cyclone.
- If wind blows from north east direction, sea becomes rough in next few days and few catches are obtained.
- Arrival of black cormorants from sea towards shore indicates the presence of strong water currents.
- When sea water is turbid upwelling may occur.
- Flying of White Sea gull above sea, is an indication of the presence of sardine shoals.
- When colour of sea is blue it indicates less fish availability.
- Appearance of mud banks *(Pallikhe)* is indicative of plenty of fish availability, beyond *Pallikhe*, sea is rough and inside the *Pallikhe* sea is calm.
- Three days after coastal upwelling more fishes are caught.
- When sea water becomes thick during rains, fishes are not visible.
- Appearance of zooplankton in mud is a prediction of impending cyclone.
- Appearance of White Sea gull *(Thora hakki)* two days ahead, is indicative of rough sea condition.
- When clouds move from east to west direction and when black sea gull is seen with the clouds it indicates impending storms and coastal upwelling.
- Presence of dark patch at sea when observed from shore, is indicative of higher wind speed.
- Fishermen say that when their feet goes down in sand while walking along sea shore it is an indication of impending cyclone within 2-3 days time.
- When halo occurs around moon, more of water currents are observed.
- When stars at night become dim, there will be more wind speed.

- If during night time, fog is present, the following day (next day) temperature will be more.
- Presence of wind blowing from south (south wind) is a prediction of impending rains.
- If windy day is followed by turbidity of waters at sea, the next day, there will be poor fish catch.
- If wind blows from south, fishes will be less, if it blows from north, fish availability will be more, if wind blows from north east, mackerel catch will be more.
- If during rains, Sea otter makes its appearance, it is an indication of less fish availability.
- Change of sea colour from green to white is indicative of higher wind speed.
- Appearance of small black heron flying above sea surface indicates arrival of cyclone 15 days later.
- When winds blow from south west direction during the time of rains, more fishes are observed to come ashore.
- Appearance of black worms on sea surface is an indication of occurrence of cyclone two days later.
- When dragon fly *(Erunti)* come in flocks from southern direction and proceeds to north it is an indication of the arrival of storms within two days.
- If shoals are seen arriving from south west direction, than it is an indication of sardine, anchovy and mackerel catch.
- When north wind blows, all fishes go into deeper waters.
- When light gnats are seen in bushes and plants at night, it is an indication of impending cyclone two days later.
- When bubbles appear from below the sea surface and burst at the top, it is an indication that cyclones will arrive within 1-2 days.
- When a flock of red coloured birds arrive from south and flies towards north it is an indication of impending cyclone 5 days later.
- When south wind blows, pomfrets and mackerel are got in plenty.
- When more white clouds are seen in the sky, than wind speed will be more on that particular day.
- The appearance of sea snake rolling itself in the waters is an indication of an impending cyclone 2-3 days later.
- The appearance of dragon flies in flocks moving from south to north direction is an indication of impending cyclone within two days.

- When butterflies move in groups over sea shore and sea surface it is an indication of cyclone approaching from the south west direction.
- Black cormorants *(Bangude hakki)* arriving in flocks ahead of rains is indicative of mackerel availability at sea.
- Appearance of White Sea gull *(Bili hakki)* over sea surface is an indication of availability of anchovies.
- If foaming of water is observed near shore, it is an indication of impending cyclones.
- Cattle and goats are seen to break away from ropes and run towards the mountain side two days ahead of Tsunami.
- Flock of greyish black butterflies flying along the sea shore is indicative of oncoming rains within a week.
- When the waters near the shore becomes black, it is an indication of impending cyclones and when the water near the shore turns red, it is an indication of impending rains.
- When White Sea gulls flies away from the rocks at sea towards land, it is an indication of impending cyclones.
- When wind blows from north, more fishes are got. When wind blows from south, fishes aggregate into shoals.
- When wind blows in one direction only, less availability of fishes occurs.
- When wind blows from north, fish is available in plenty and when wind blows from the south, fish availability is less.
- When wind blows from sea towards land, the sea becomes silent and fishermen do not experience any problems in fishing.

Fig.1 During new moon fish availability is more.

Explanation: In the case of stationary gears like gillnets, the fish catch during new moon is found to be high. One of the reasons is that, due to less light, fishes come near surface layers of the water and due to poor visibility they get caught in entangling nets.

Fig.2 When wind blows from west side to shore, fish availability is more.

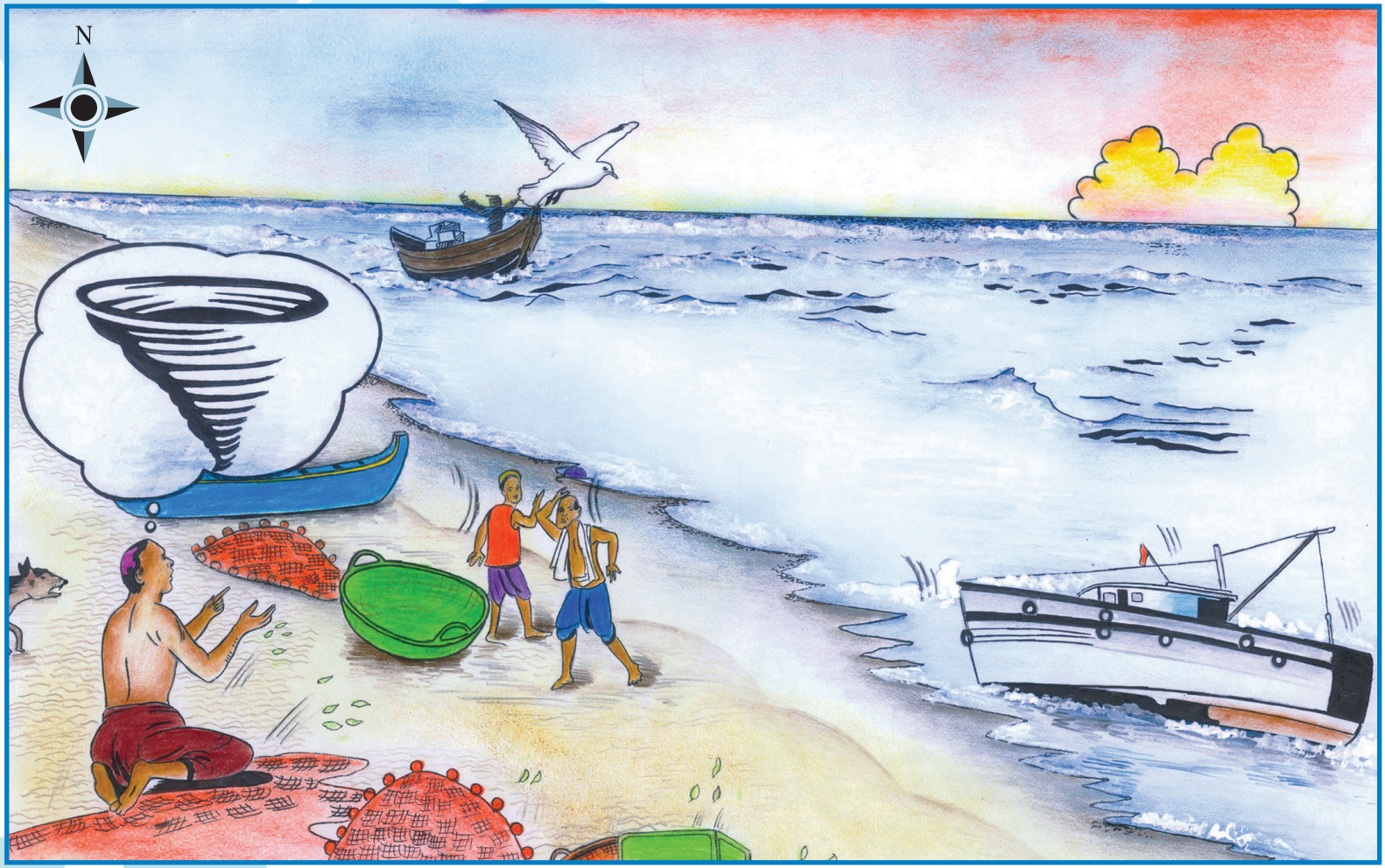


Fig.3 Winds blowing from south to north coupled with appearance of white sea gull is indicative of rough seas and impending cyclone.

Fig.4 If wind blows from north east direction, sea becomes rough in next few days and few catches are obtained.
Explanation: The rough condition at sea creates operational difficulties which leads to poor catches.

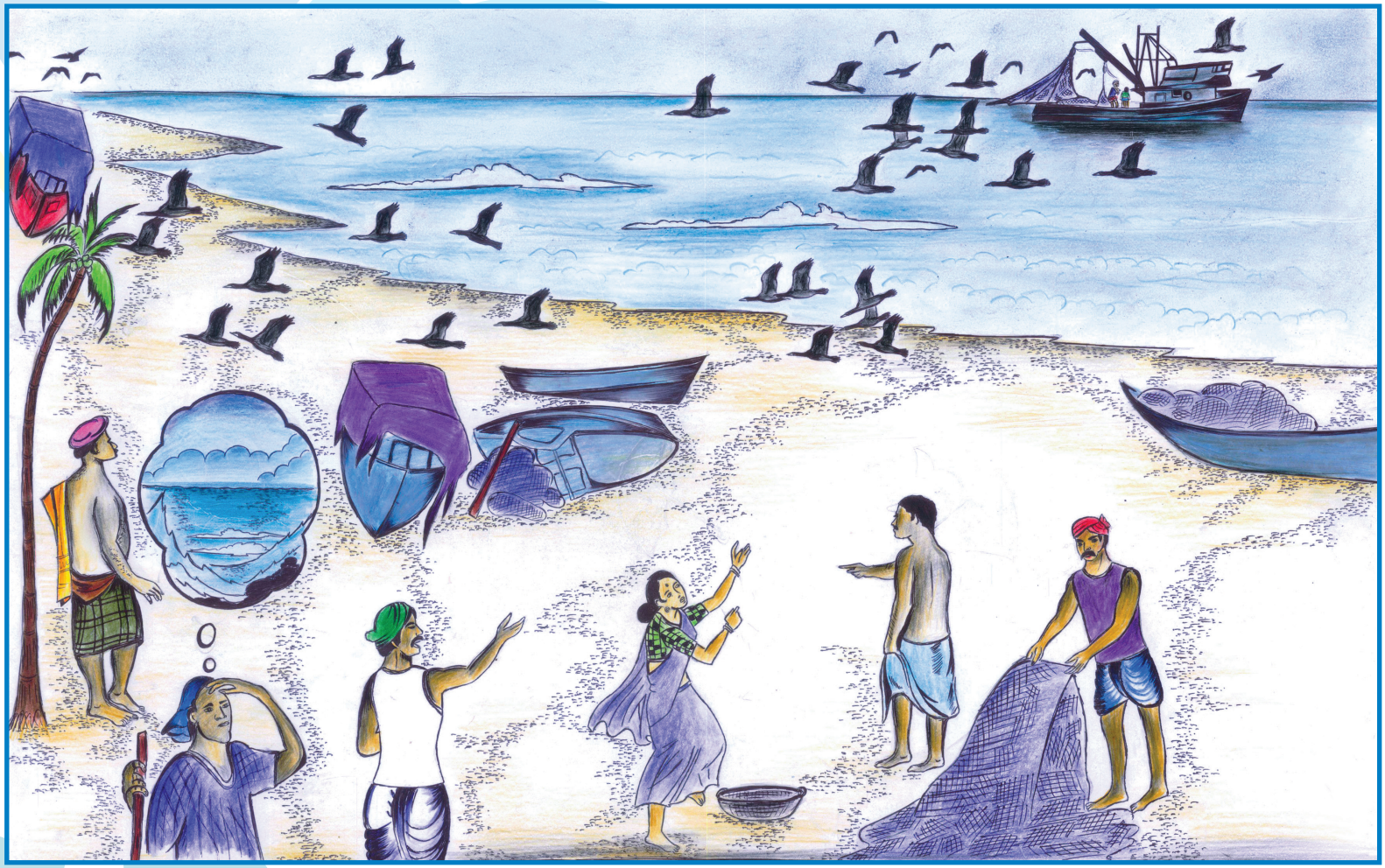


Fig.5 Arrival of black cormorants from sea towards shore indicates the presence of strong water currents.
Explanation: Difficulty in staying afloat on heavy currents may force the birds to take shelter on land.

Fig.6 When sea water is turbid upwelling may occur.
Explanation: Due to upwelling, organic rich turbid bottom water comes to the surface giving the water a muddy appearance.

Fig.7 Flying of White Sea gull above sea, is an indication of the presence of sardine shoals.
Explanation: The White Seagull feeds on sardines and if sardine shoal is found, they fly around the shoal for feeding them.

Fig.8 When colour of sea is blue it indicates less fish availability.

Explanation: Blue colour of the sea indicates less phytoplankton productivity, which leads to less catch from these areas of poor productivity.

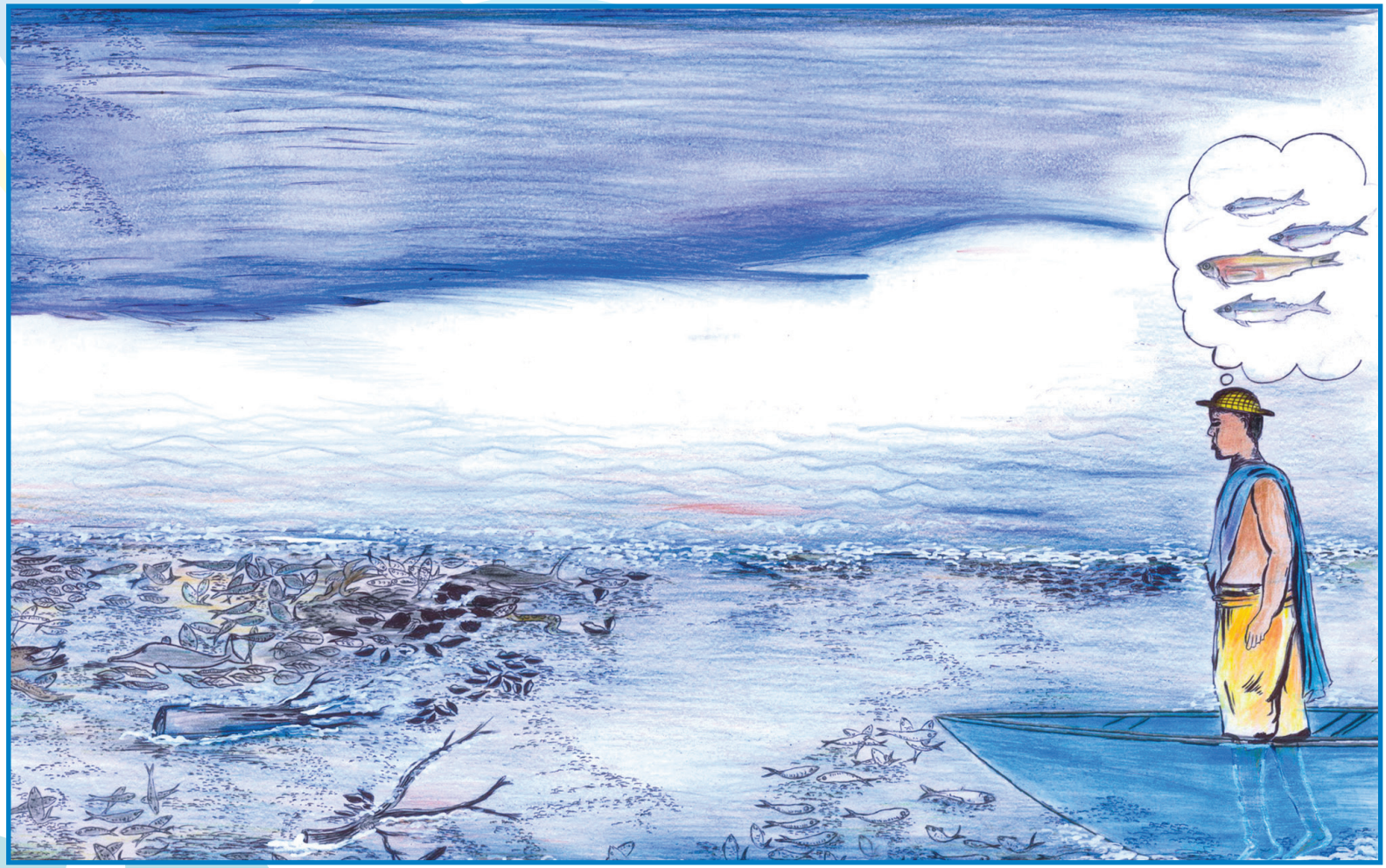


Fig.9 Appearance of mud banks *(Pallikhe)* is indicative of plenty of fish availability, beyond *Pallikhe*, sea is rough and inside the *Pallikhe* sea is calm.
Explanation: Pallikhe indicates the phenomenon of mud bank formation. It is found that the mud banks are very productive and fishes aggregate in mud banks for feeding and hence plenty of fishes are found in the Pallikhe.

Fig.10 Three days after coastal upwelling more fishes are caught.

Explanation: Coastal upwelling has different phases. During the first phase of coastal upwelling, churning of poorly oxygenated, highly nutritious bottom water comes to the surface. Low oxygenated nature of this water is not good for fishes and hence they tend to move away. During the second phase, the presence of sunlight results in heavy blooming of phytoplankton, which also improves the oxygen level. During the third phase, the fishes come in large numbers to this area for feeding on the plankton and within three to four days the up-welled area will turn in to a good fishing ground.

Fig.11 When sea water becomes thick during rains, fishes are not visible.

Explanation: During the rains, the run off from land will be muddy in nature containing lots of nutrients. It will take at least two to three days for establishing zooplankton activity. Once Phytoplankton and Zooplankton are established they become a feeding ground for the fishes.

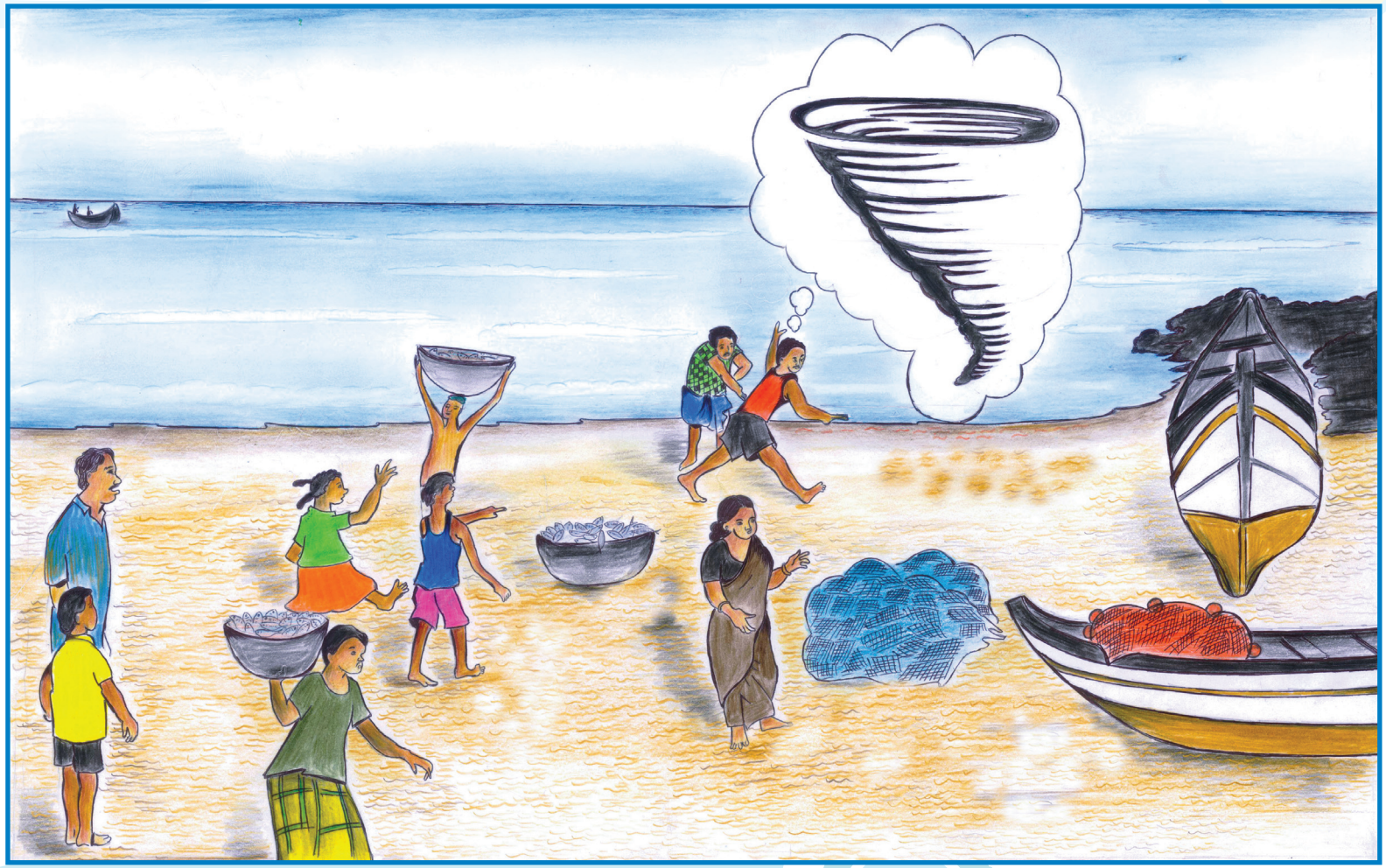


Fig.12 Appearance of zooplankton in mud is a prediction of impending cyclone.

Fig.13 Appearance of White Sea gull *(Thora hakki)* two days ahead, is indicative of rough sea condition.

Fig.14 When clouds move from east to west direction and when black sea gull is seen with the clouds it indicates impending storms and coastal upwelling.

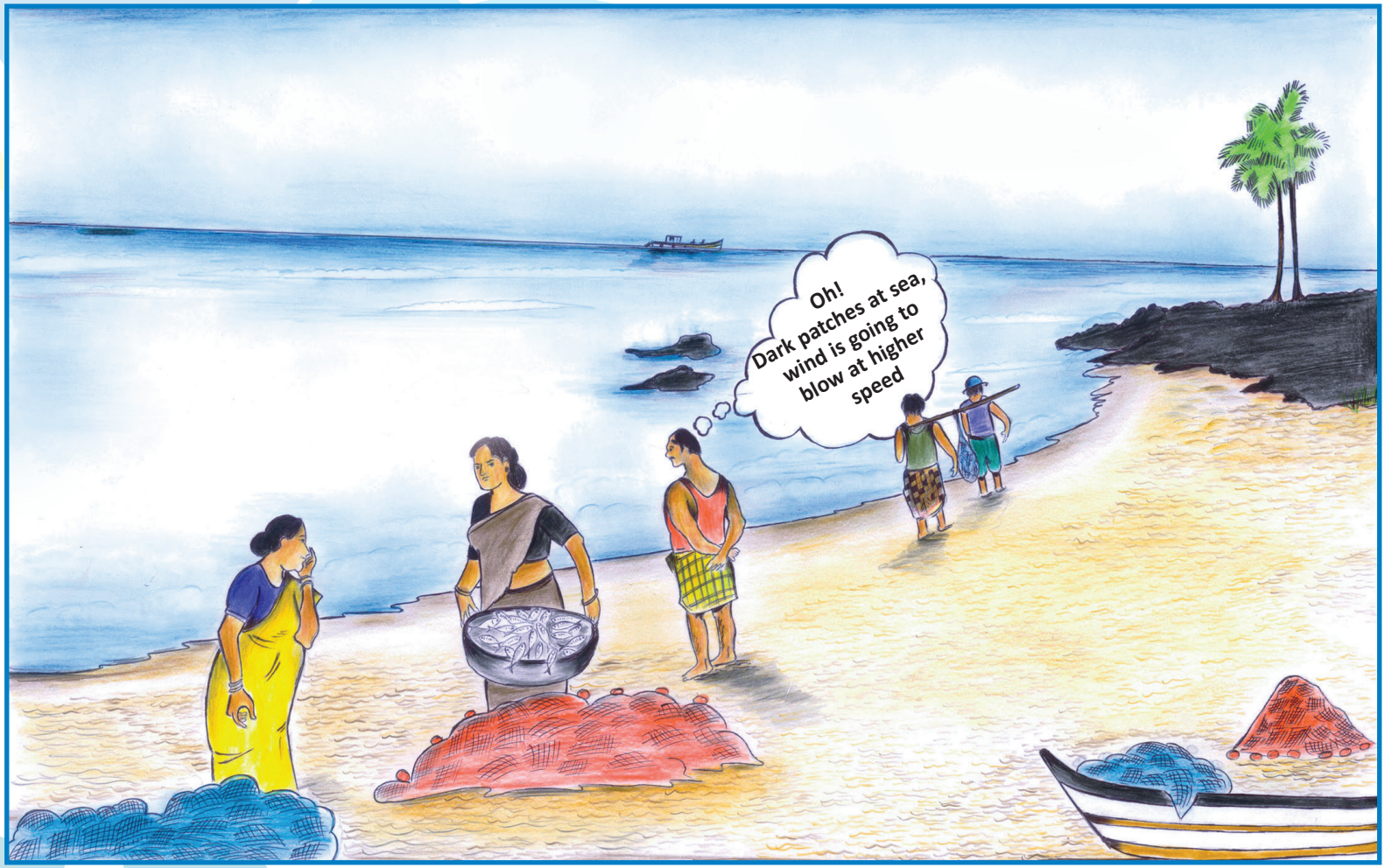


Fig.15 Presence of dark patch at sea when observed from shore, is indicative of higher wind speed.

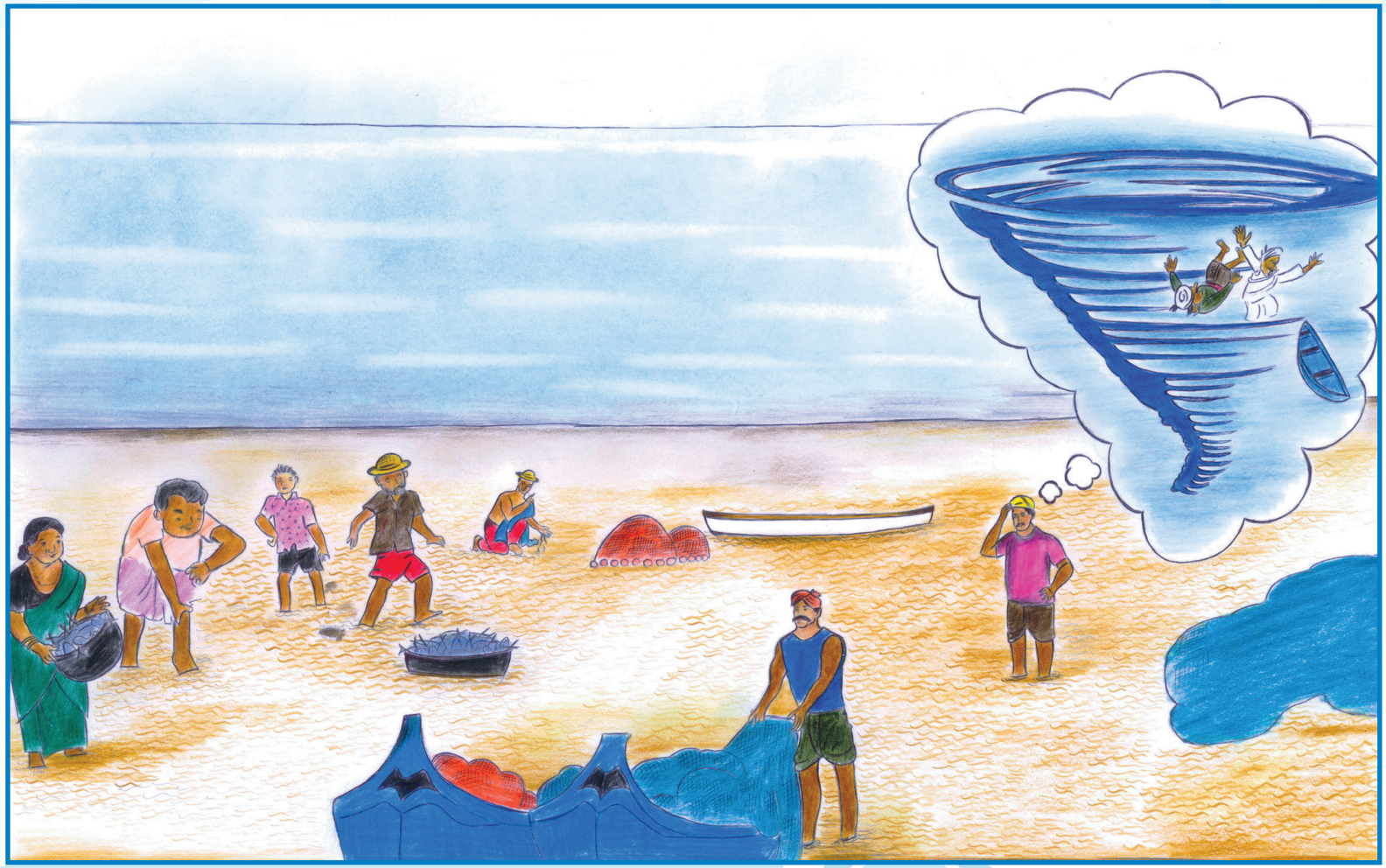


Fig.16 Fishermen say that, when their feet goes down in sand while walking along sea shore it is an indication of an impending cyclone arriving within 2-3 days time.

Fig.17 When halo occurs around moon, more of water currents are observed.

Fig.18 When stars at night become dim, there will be more wind speed.

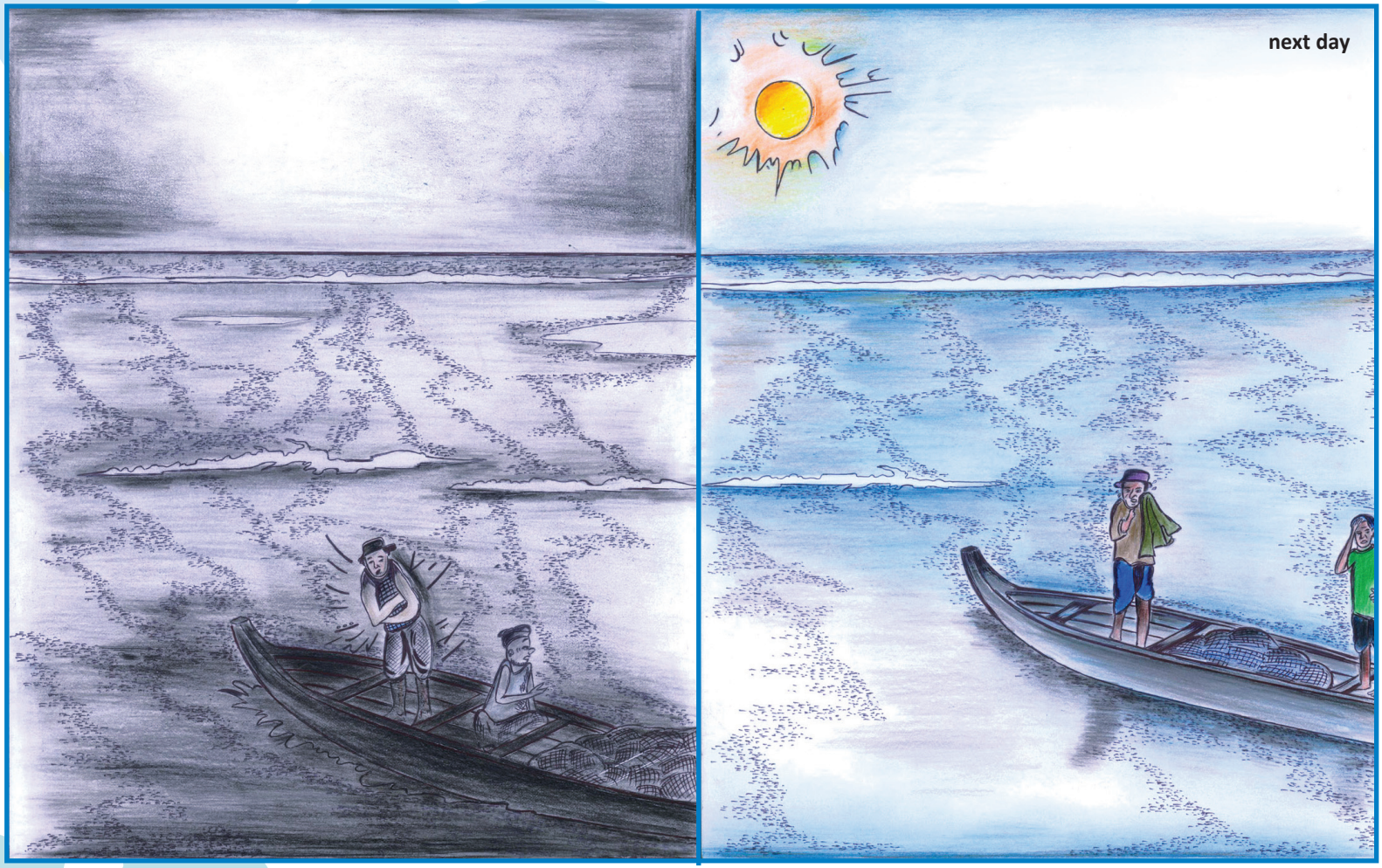


Fig.19 If during night time, fog is present, the following day (next day) temperature will be more.

Fig.20 Presence of wind blowing from south (south wind) is a prediction of impending rains.

Fig.21 If windy day is followed by turbidity of waters at sea, the next day, there will be poor fish catch.

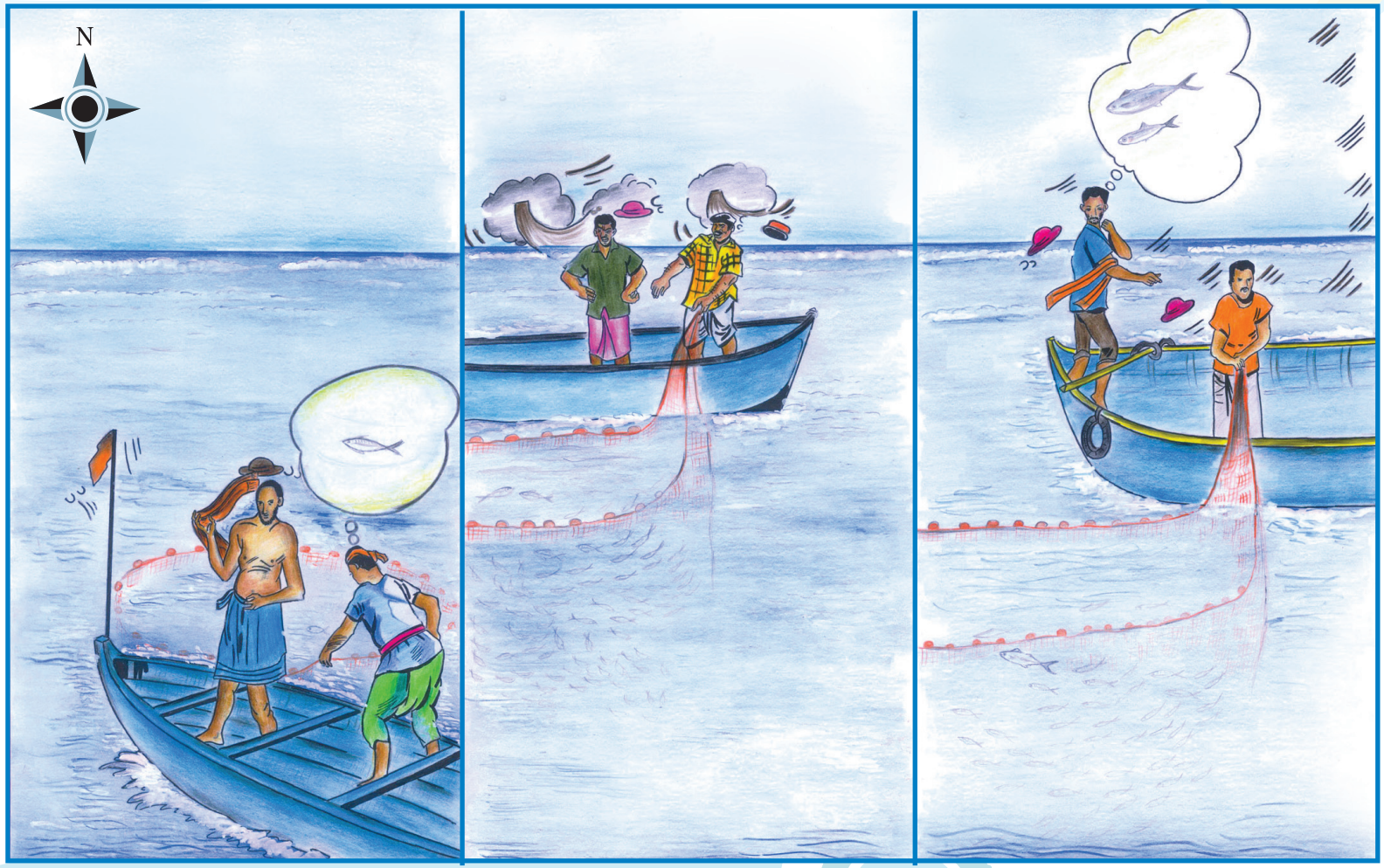


Fig.22 If wind blows from south, fishes will be less, if it blows from north, fish availability will be more, if wind blows from north east, mackerel catch will be more.

Fig. 23 If during rains, Sea otter makes its appearance it is an indication of less fish availability.
Explanation: Sea Otter emits a pungent smell that drives away fishes.

Fig.24 Change of sea colour from green to white is indicative of higher wind speed.

Fig.25 Appearance of small black heron flying above sea surface indicates arrival of cyclone 15 days later.

Fig.26 When winds blow from south west direction during the time of rains, more fishes are observed to come ashore.

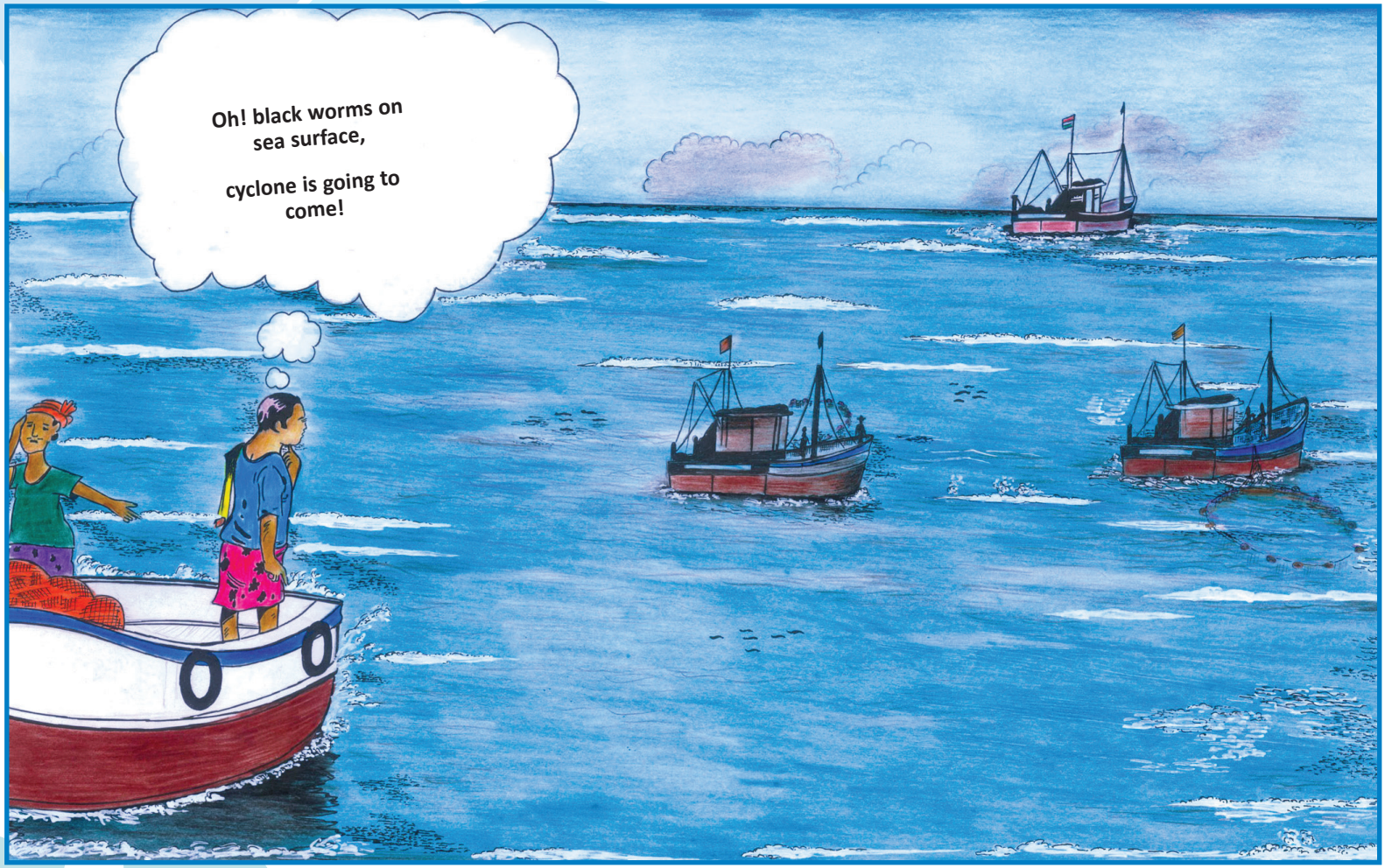


Fig.27 Appearance of black worms on sea surface is an indication of occurrence of cyclone two days later.

Fig.28 When dragon fly *(Erunti)* come in flocks from southern direction and proceeds to north it is an indication of the arrival of storms within two days.

Fig.29 If shoals are seen arriving from south west direction, than it is an indication of sardine, anchovy and mackerel catch.

Fig.30 When north wind blows all fishes go into deeper waters.

Fig.31 When light gnats are seen in bushes and plants at night, it is an indication of impending cyclone two days later.

Fig.32 When bubbles appear from below the sea surface and burst at the top, it is an indication that cyclones will arrive within 1-2 days.

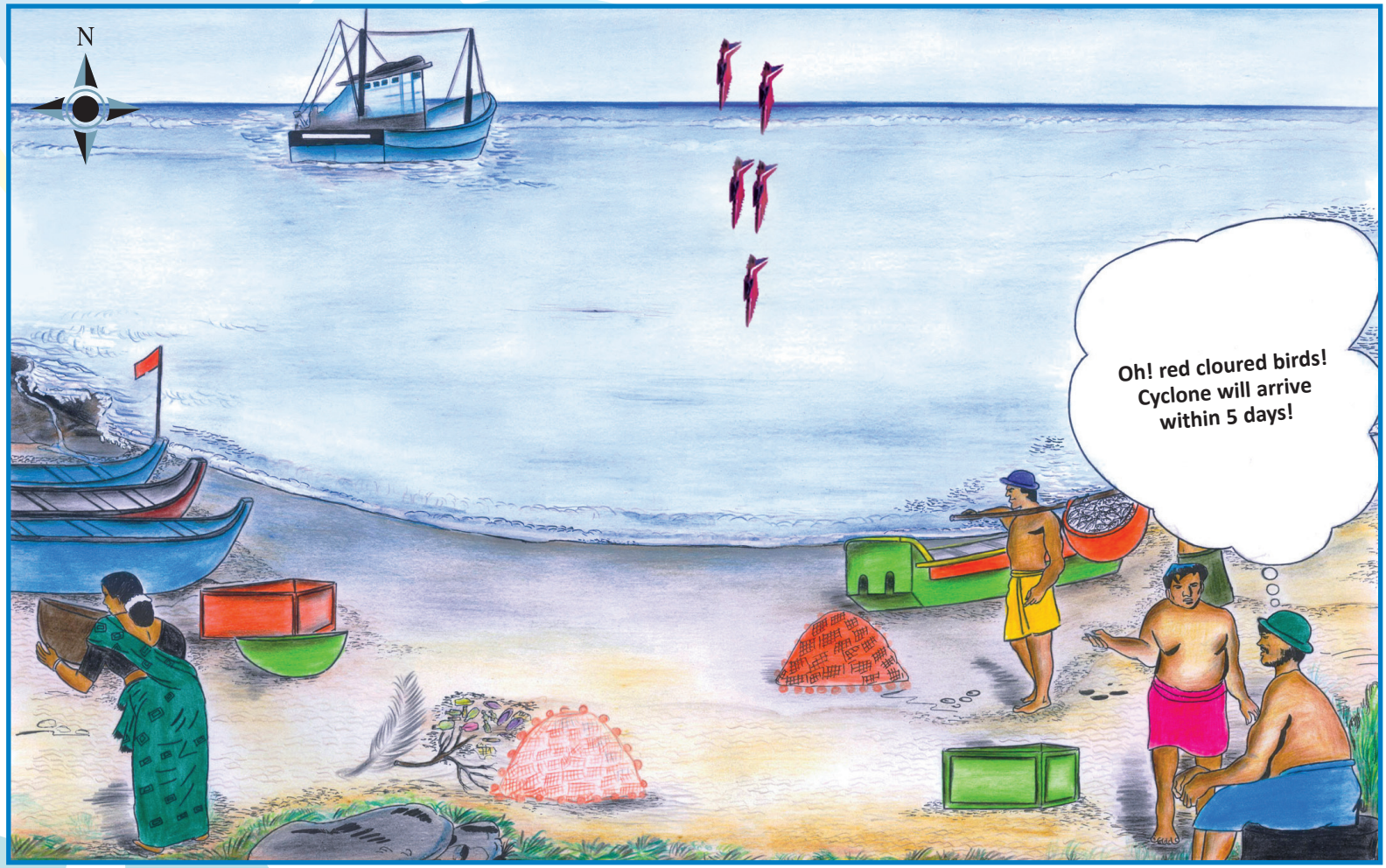


Fig.33 When a flock of red coloured birds arrive from south and flies towards north it is an indication of impending cyclone 5 days later.

Fig.34 When south wind blows, pomfrets and mackerel are got in plenty.

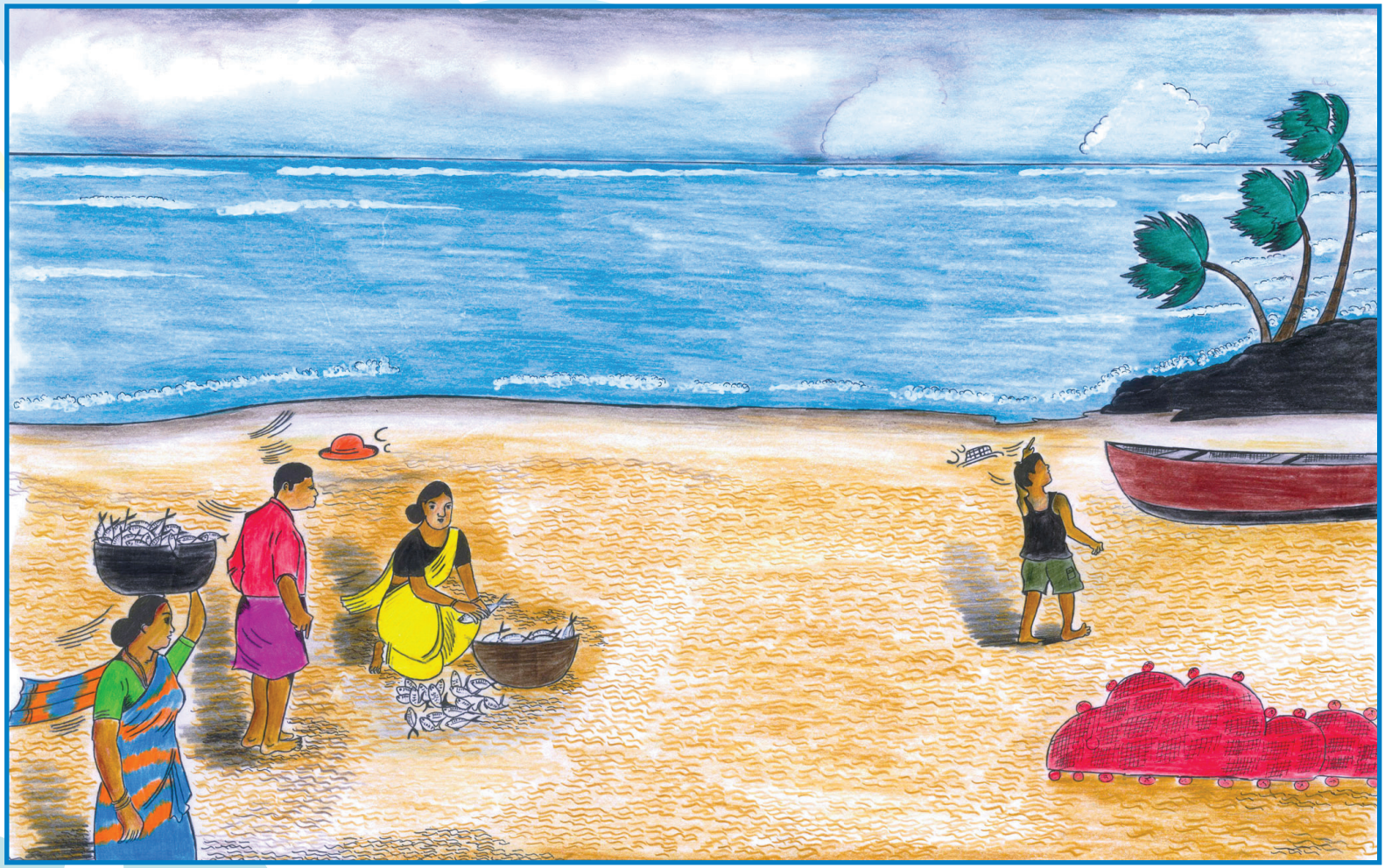


Fig.35 When more white clouds are seen in the sky, than wind speed will be more on that particular day.

Fig.36 The appearance of sea snake rolling itself in the waters is an indication of an impending cyclone 2-3 days later.

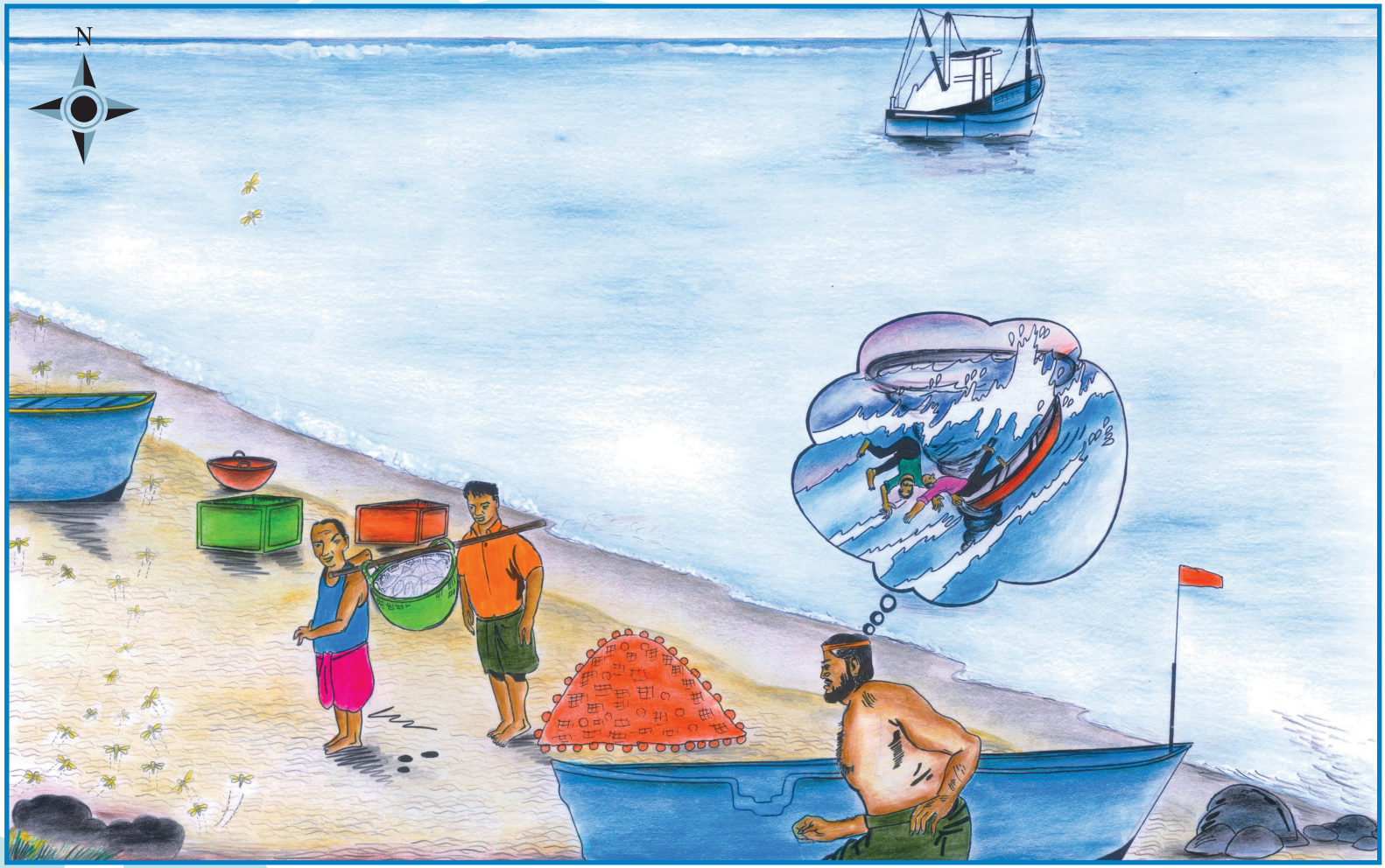


Fig.37 The appearance of dragon flies in flocks moving from south to north direction is an indication of impending cyclone within two days.

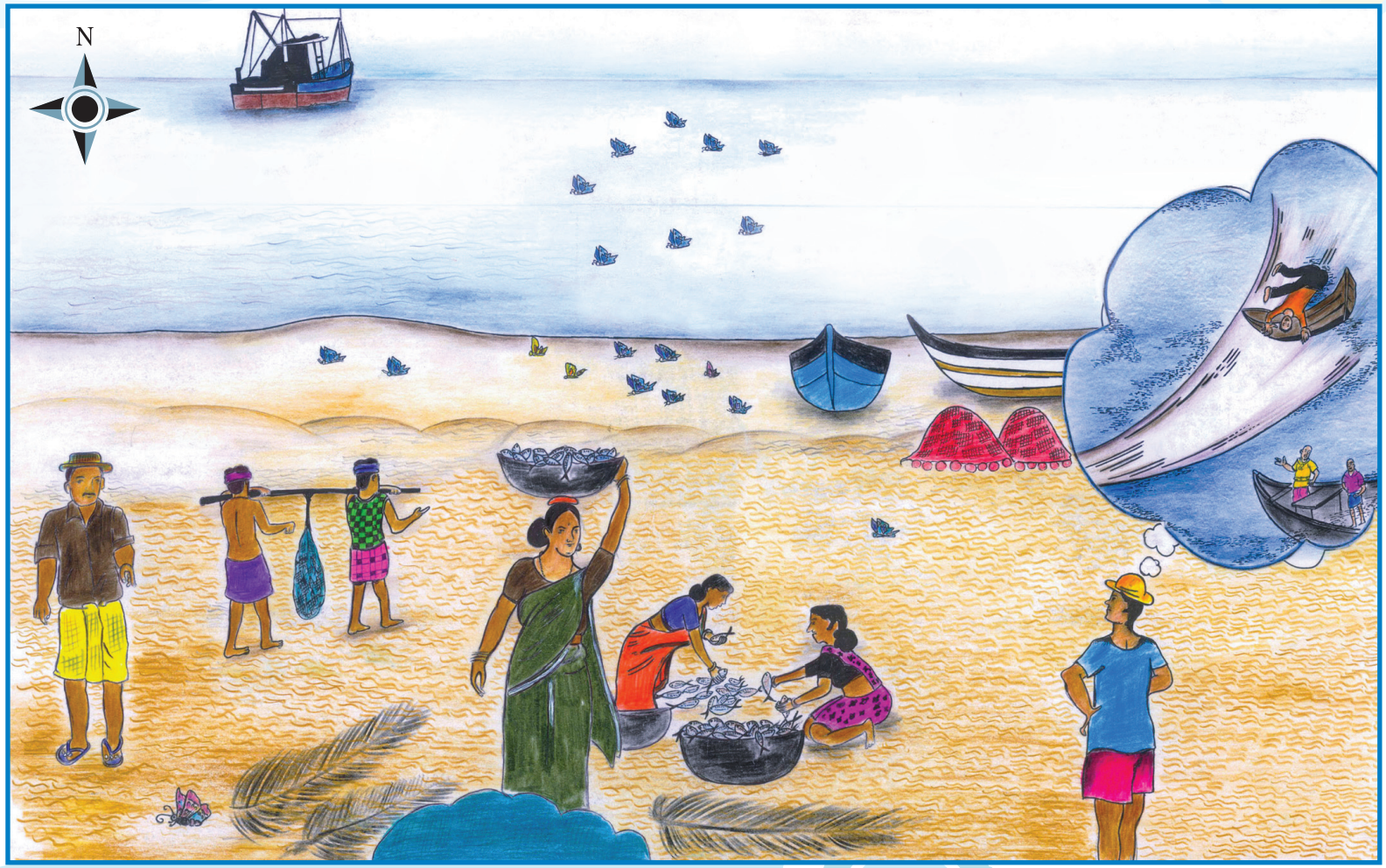


Fig.38 When butterflies move in groups over sea shore and sea surface it is an indication of cyclone approaching from the south west direction.

Fig.39 Black cormorants *(Bangude hakki)* arriving in flocks ahead of rains is indicative of mackerel availability at sea.

Fig.40 Appearance of White Sea gull *(Bili hakki)* over sea surface is an indication of availability of anchovies.

Fig.41 If foaming of water is observed near shore, it is an indication of impending cyclones.

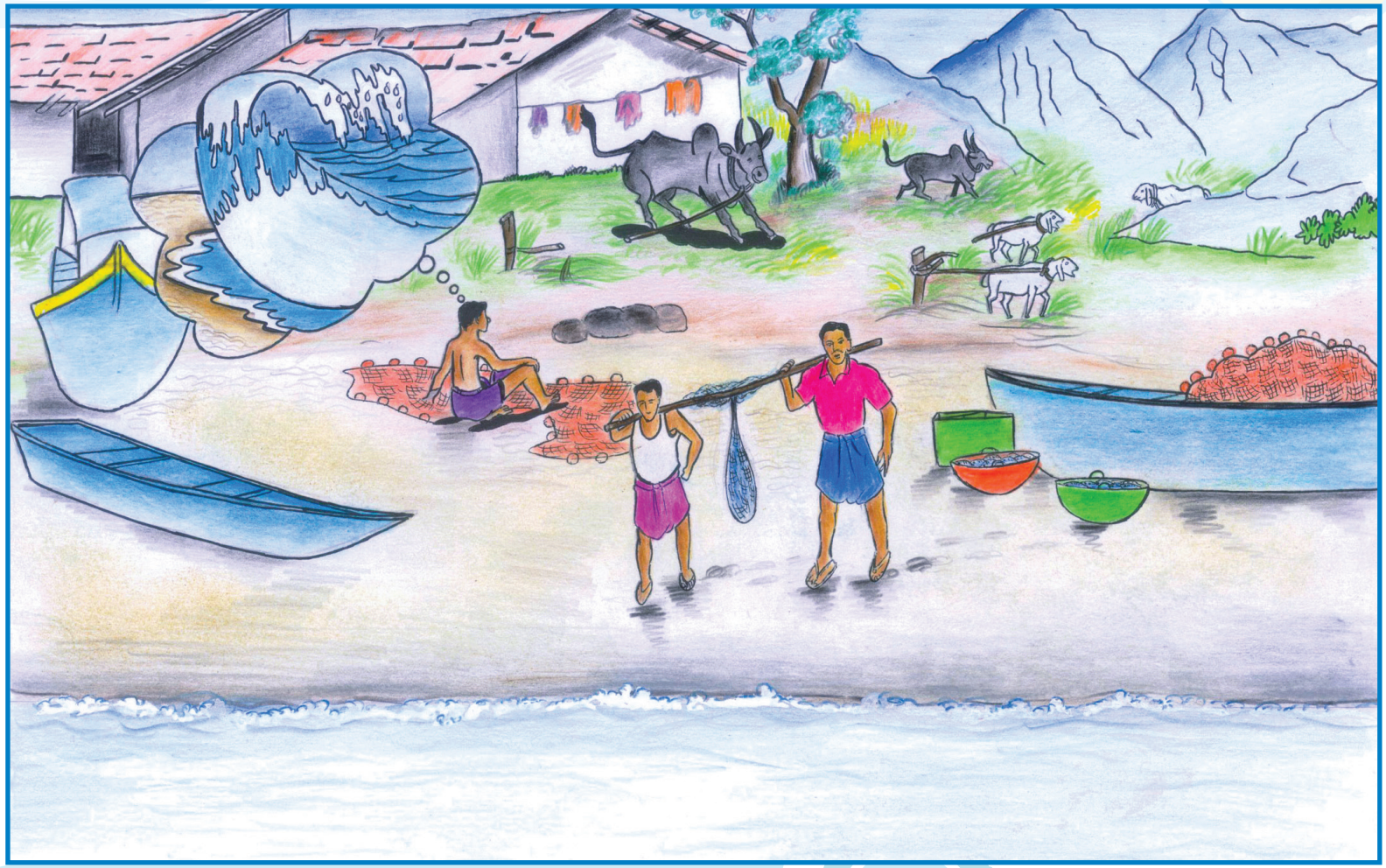


Fig.42 Cattle and goats are seen to break away from ropes and run towards the mountain side two days ahead of Tsunami.

Fig.43 Flock of greyish black butterflies flying along the sea shore is indicative of oncoming rains within a week.

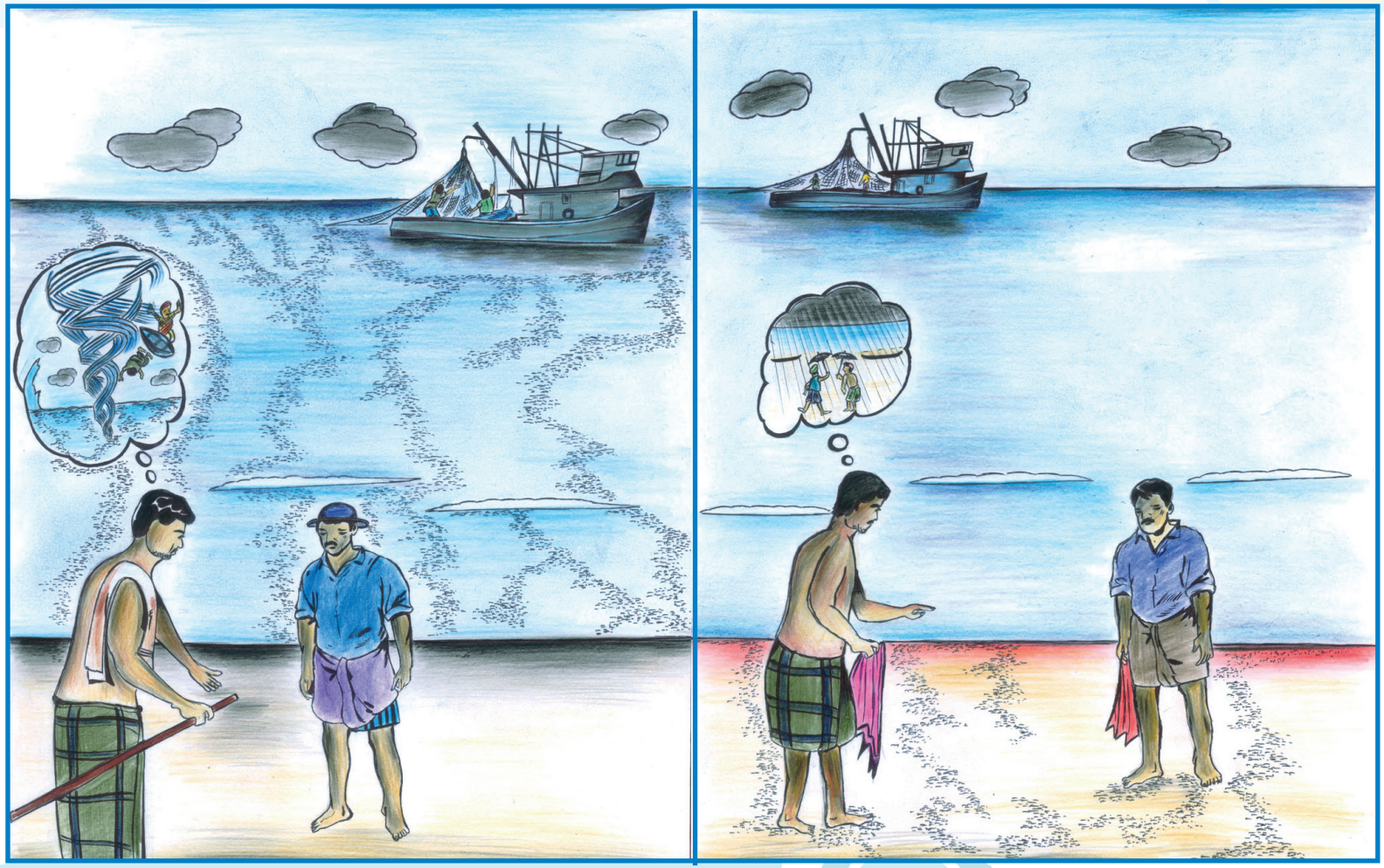


Fig.44 When the waters near the shore becomes black, it is an indication of impending cyclones and when the water near the shore turns red, it is an indication of impending rains.

Fig.45 When White Sea gulls flies away from the rocks at sea towards land, it is an indication of impending cyclones.

Fig.46 When wind blows from north, more fishes are got. When wind blows from south, fishes aggregate into shoals.

Fig.47 When wind blows in one direction only, less availability of fishes occurs.

Fig.48 When wind blows from north, fish is available in plenty and when wind blows from the south, fish availability is less.

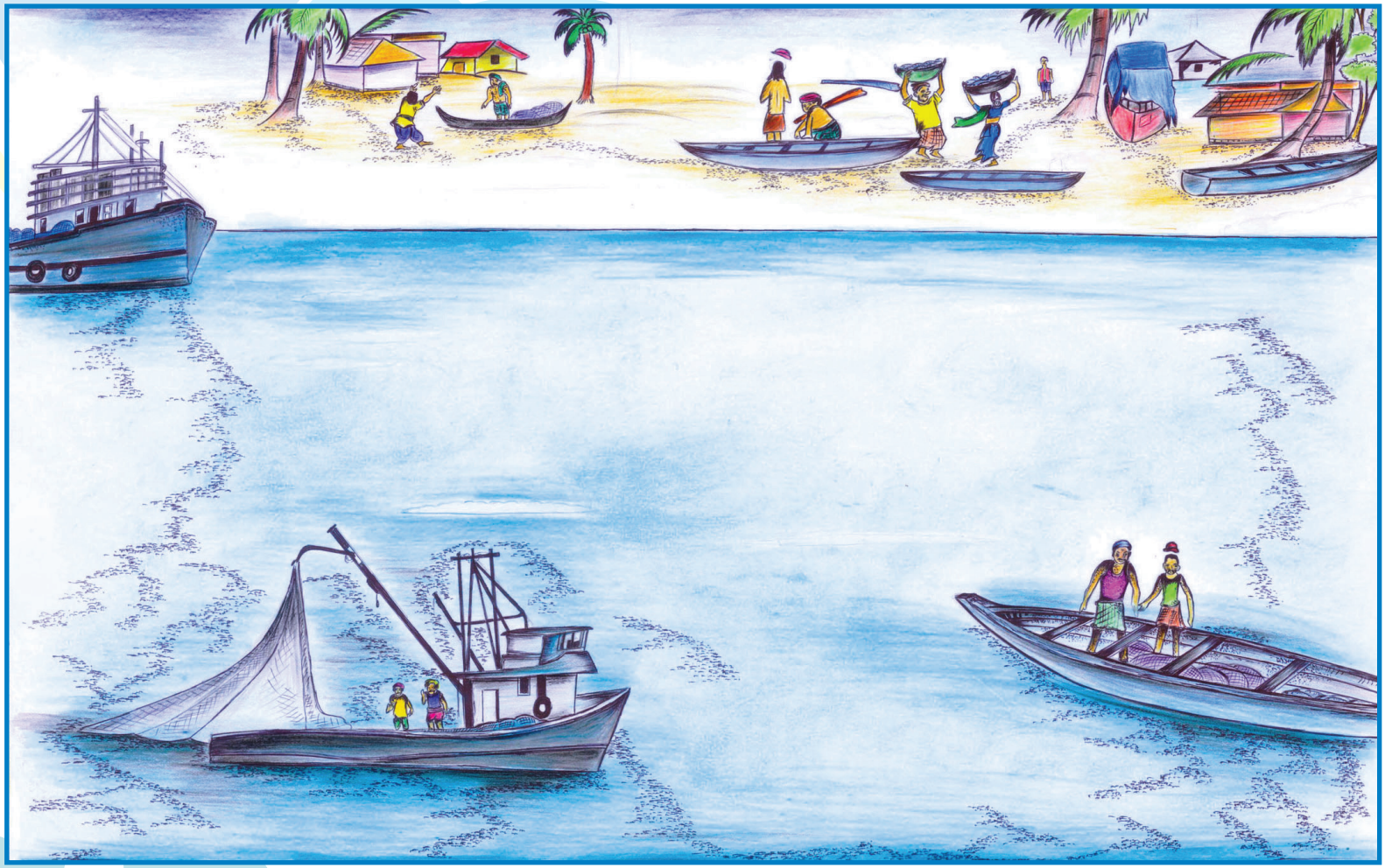


Fig.49 When wind blows from sea towards land, the sea becomes silent and fishermen do not experience any problems in fishing.

4 ITKs' of **Maharashtra**

Maharashtra State, in northwest India, has a coastline of 840 km and has five coastal districts namely, Thane, Greater Mumbai, Raigad, Ratnagiri and Sindhudurg. There are 456 marine fishing villages and 152 marine fish landing centres in Maharashtra. There are 81,492 marine fishermen families in the state with a population of 3,86,259. Among 81,492 fishermen families, 91% are traditional fishermen. There are 17,362 crafts in the fishery of which 13,016 are mechanized, 1,563 motorized and non-motorized formed the rest.

The following Indigenous Technical Knowledge (ITK) were reported from Maharashtra.

- When the Sun is encircled by a kind of ring which is locally called as “Vedha” in Marathi, it is an indication of impending storms.
- Incidence of turbidity of near shore waters is an indication of impending storms.
- When the sea water gives a greenish tinge of colour, it indicates more fish availability.
- Turbidity at sea indicates more fish availability and clear water indicates less fish availability.
- When wind blows towards west or north direction, it indicates more fish availability and when the wind blows towards the south, it indicates less fish availability.

Fig.1 When the Sun is encircled by a kind of ring which is locally called as "Vedha" in Marathi, it is an indication of impending storms.
Explanation: The halo around the Sun is an indication of cirrus clouds which is in turn a sign of impending storms.

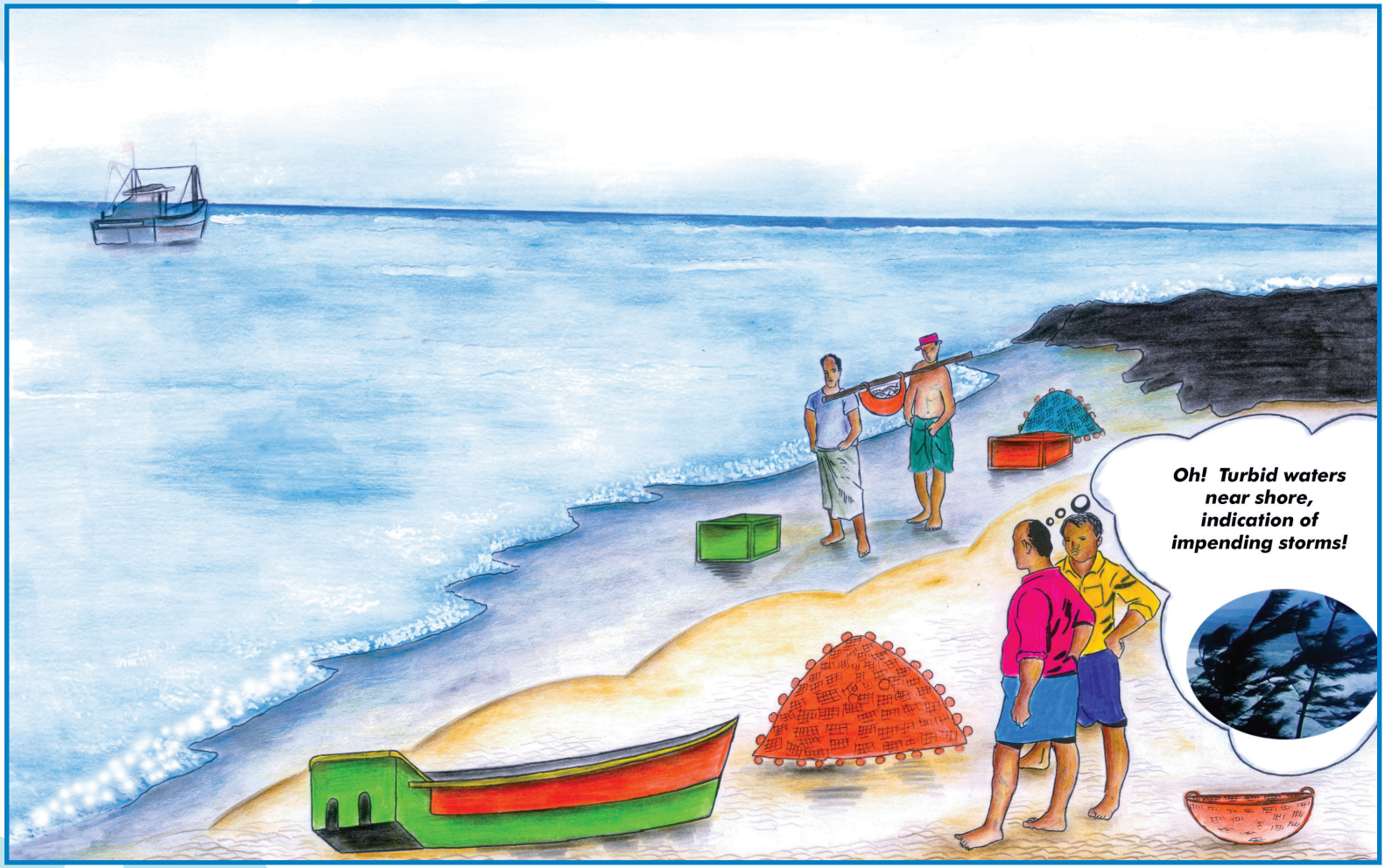


Fig.2 Incidence of turbidity of near shore waters is an indication of impending storms.

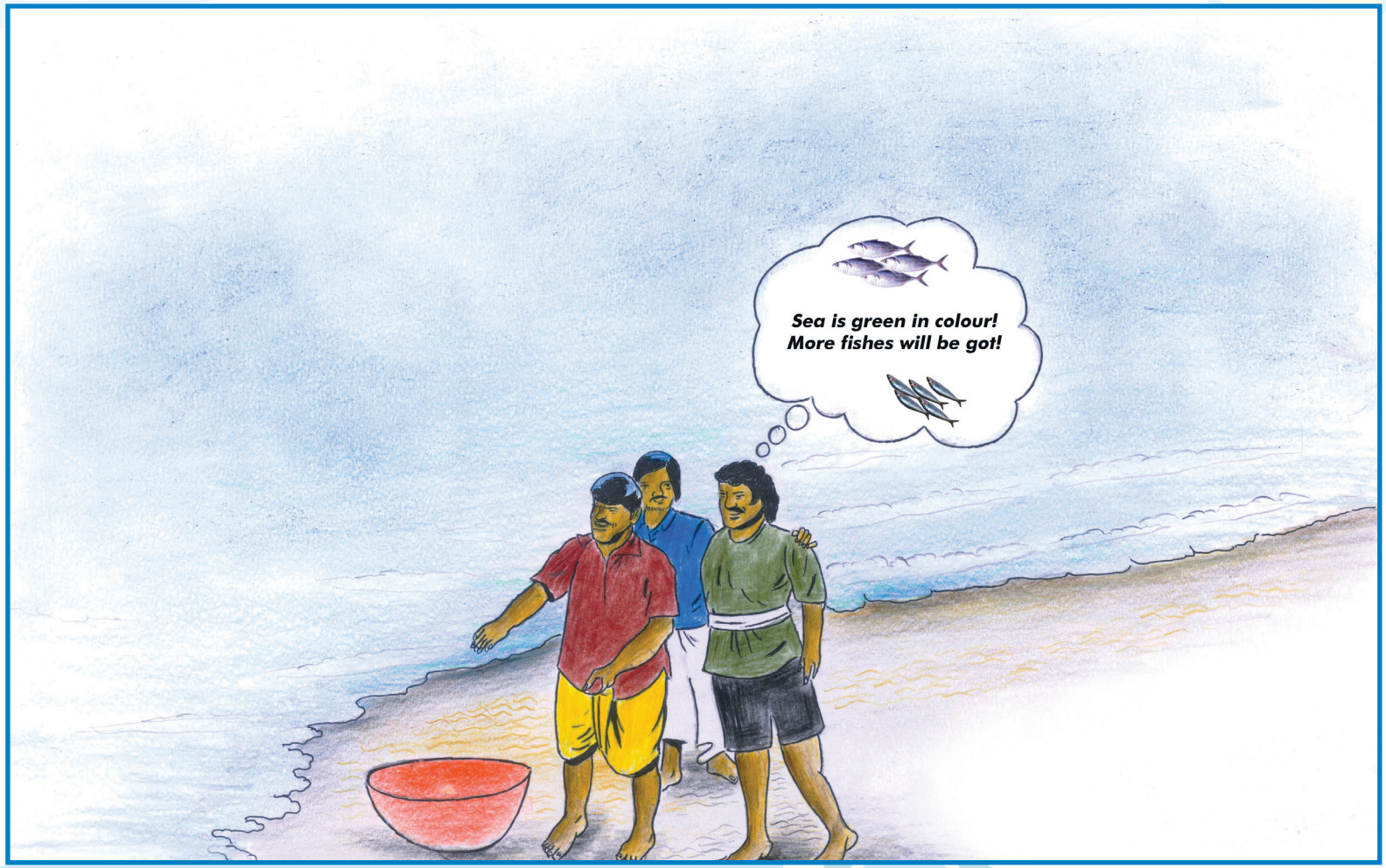


Fig.3 When the sea water gives a greenish tinge of colour, it indicates more fish availability.
Explanation: Green colour of the sea water indicates good primary production and more food availability for fishes and hence the incidence of more fish catch.

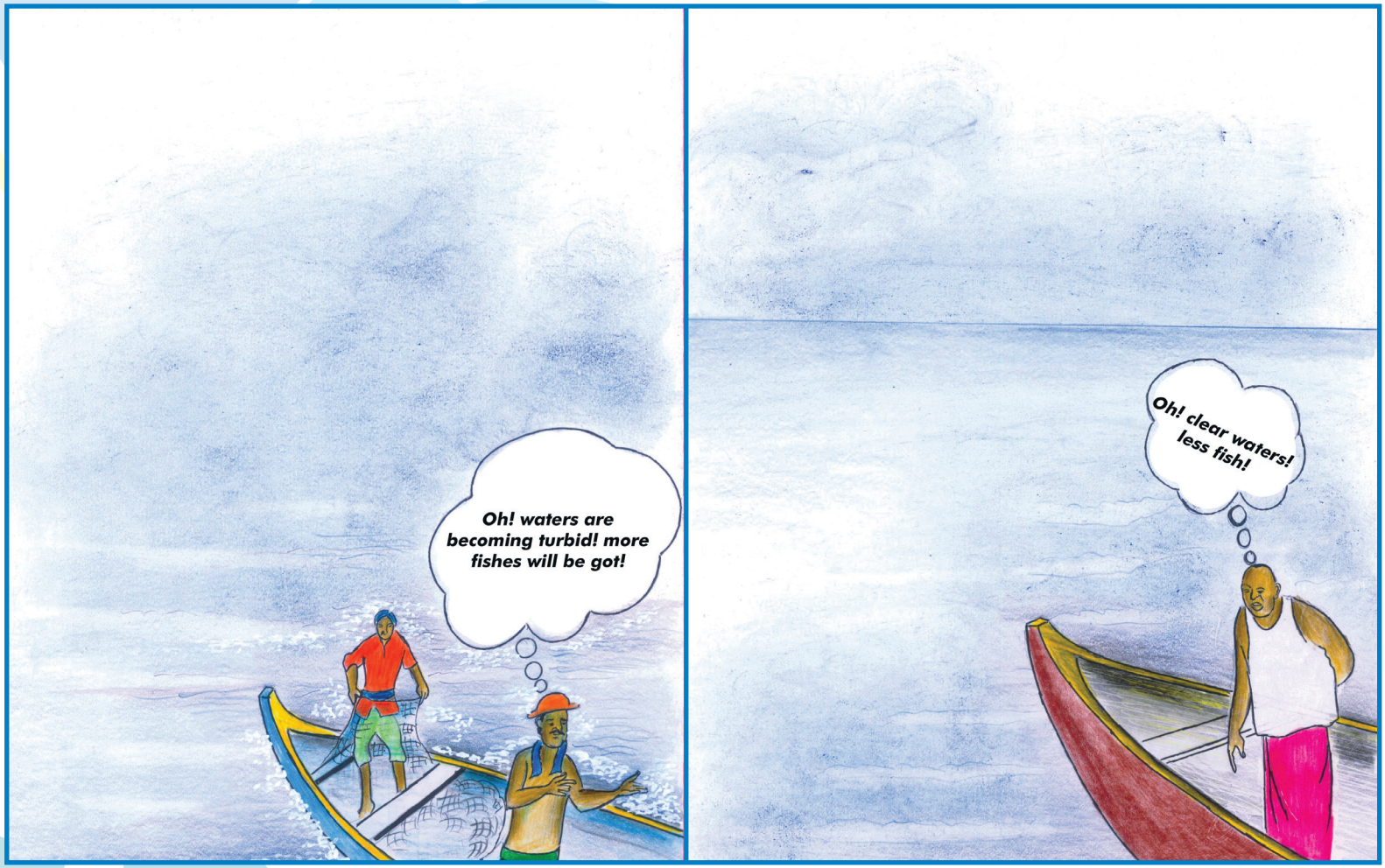


Fig.4 Turbidity at sea indicates more fish availability and clear water indicates less fish availability.
Explanation: Turbidity at sea indicates more phytoplankton productivity, which leads to more fish catch from these areas. When the water at sea is clear, it indicates less phytoplankton productivity leading to less fish catch from these areas.

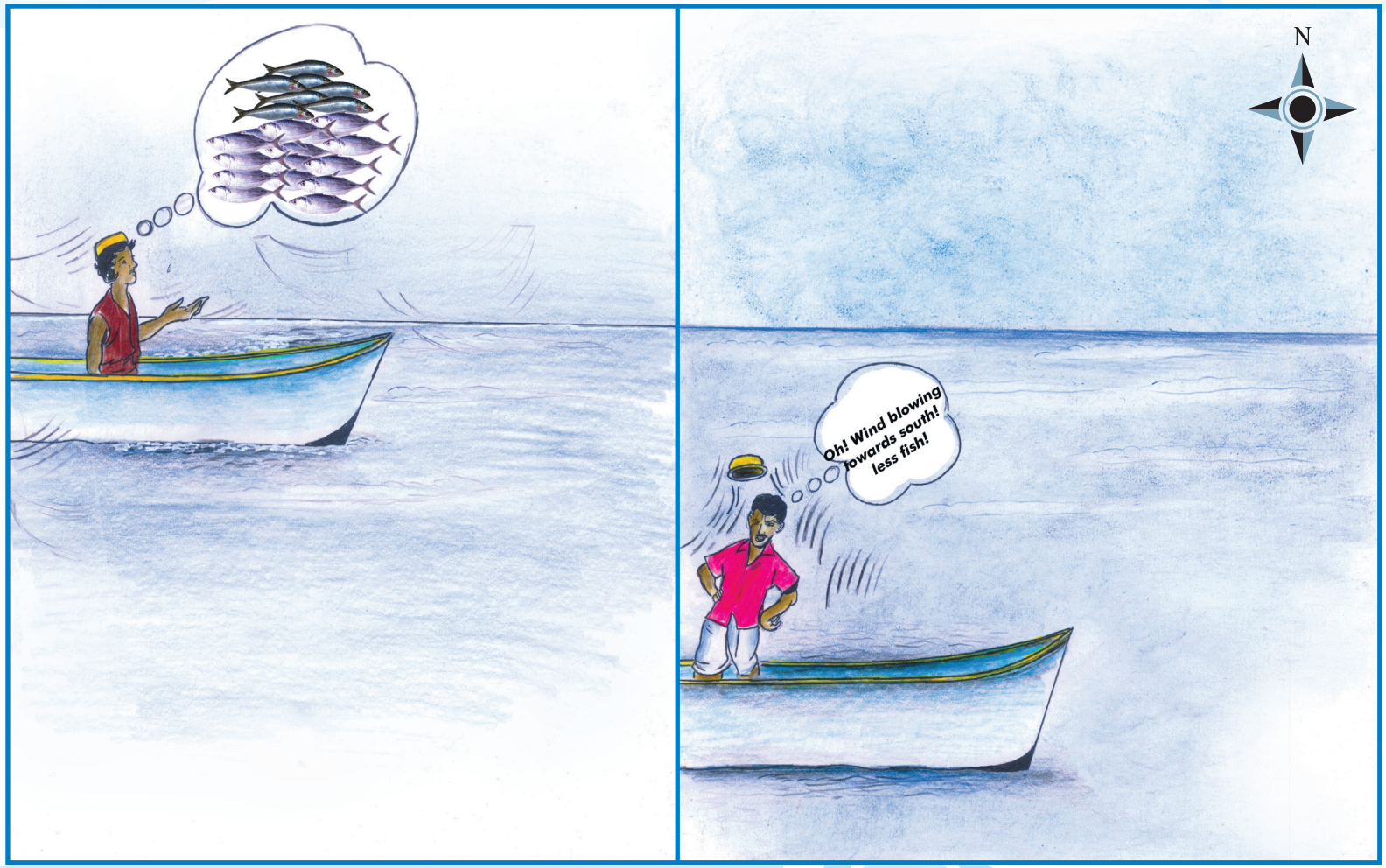


Fig.5 When wind blows towards west or north direction, it indicates more fish availability and when the wind blows towards the south, it indicates less fish availability.

Explanation: During summer months when the wind blows towards west or north the shore temperature increases, and warm air moves up and is replaced by cold wind blowing towards the shore. This results in low temperature of the surface water which provide the ambient temperature for the fishes to move from deeper waters and come to the surface which in turn ensures good fish catch.

5 ITKs' of **Gujarat**

Gujarat has the longest coastline of 1600 km among the maritime states of India. It has twelve coastal districts namely, Valsad, Navasari, Surat, Bharuch, Anand, Bhavanagar, Amreli, Junagadh, Porabander, Jamnagar, Rajkot and Kutch. There are 247 marine fishing villages and 121 landing centres in Gujarat. There are 62,231 fishermen families in the state with a total population of 3, 36,181. Among 62,231 fishermen families, 96% are traditional fishermen. There are 28,400 crafts in the fishery, of which 18,278 are mechanized, 8,238 motorized and non-motorized formed the rest.

The following Indigenous Technical Knowledge (ITK) were reported from Gujarat.

- Fish availability is decided based on water currents.
- With increasing rainfall, fish availability in near shore areas decreases.
- Higher wind speed results in less fish availability, when sea is rough fish catches are less.
- a. When wind blows from west towards shore, fish availability is more.

  b. When wind blows from south to north, sea becomes rough and it is an indication of an impending cyclone.
- a. Reef cod fishes are abundant during winter season especially on new moon nights.

  b. On new moon days stars become faint which is an indication of high wind speed.

  c. Gathering of birds over sea surface indicates fish availability in that region.
- During full moon period more catch of squids are obtained.
- More fish availability is obtained with increase in temperature.
- Fishers predict the arrival of cyclone by observing peculiar circular movements of birds over the sea surface which thereafter moves towards the sky.

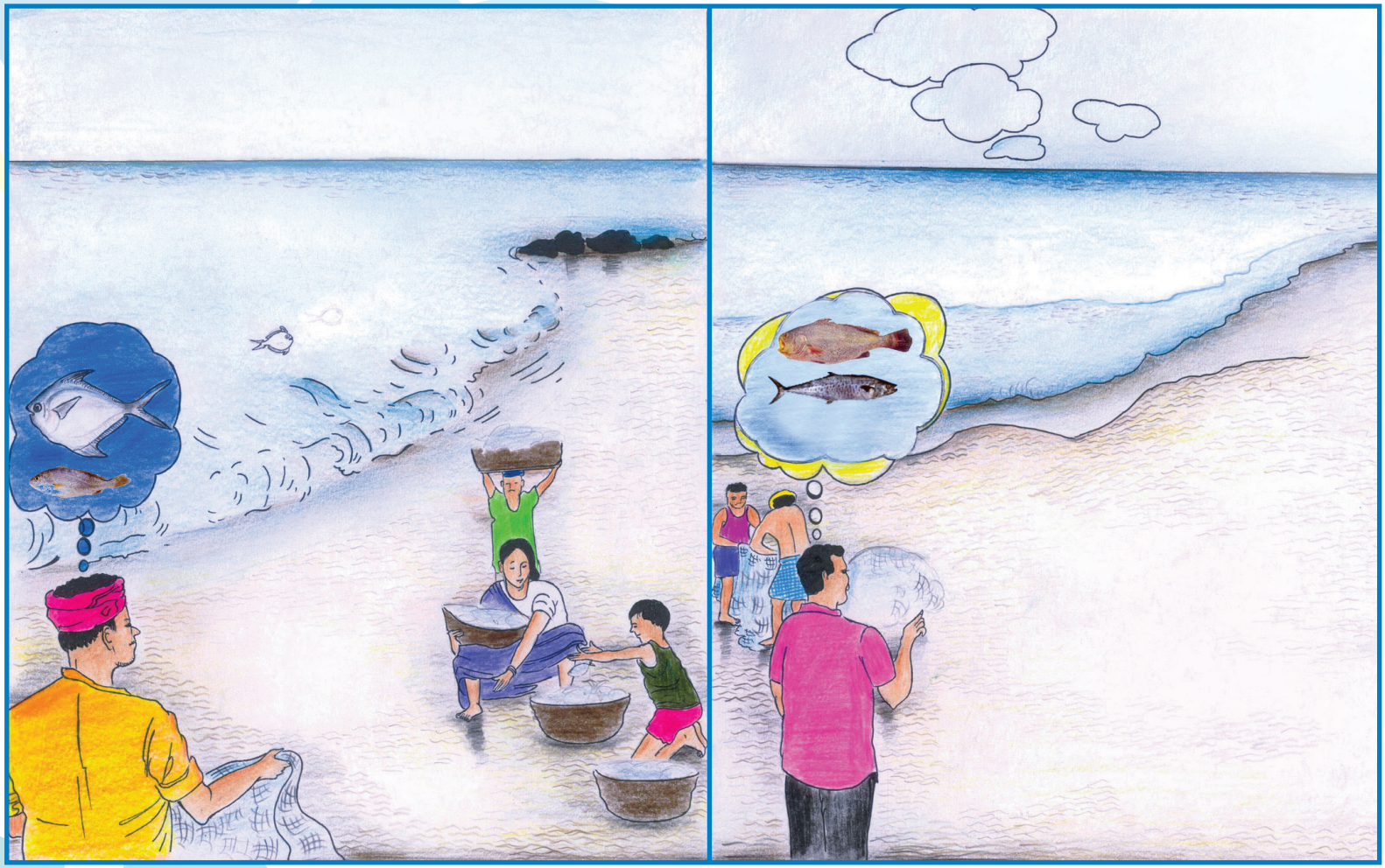


Fig.1 Fish availability is decided based on water currents.

Explanation: Current decides the water temperature. According to the source of water, fishes which prefer a particular temperature remain with the water current and those which do not prefer a particular temperature moves away. In this way water currents play a major role in determining fish availability.

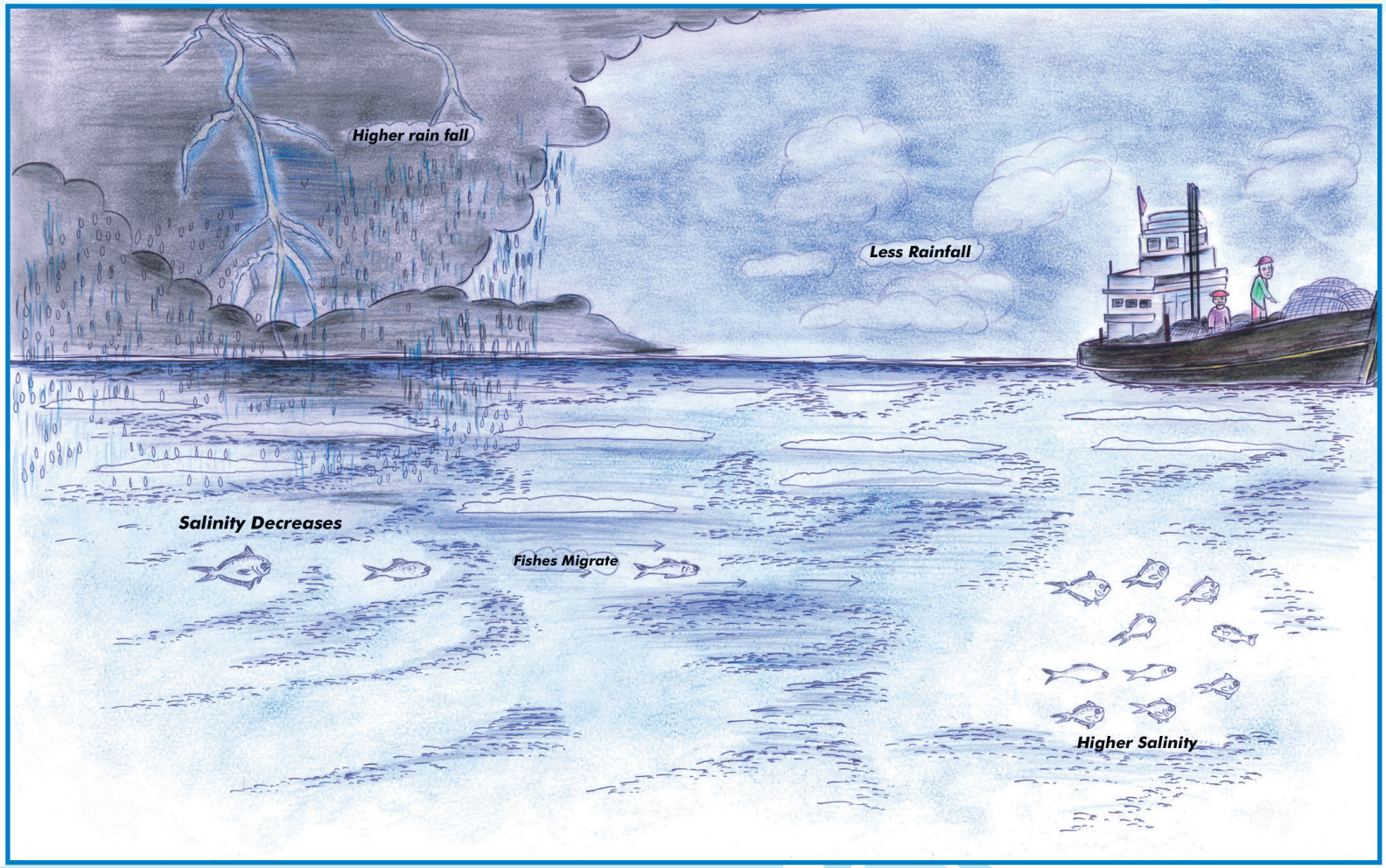


Fig.2 With increasing rainfall, fish availability in near shore areas decreases.
Explanation: The marine species of fishes are mostly stenohaline, which cannot tolerate the decreased salinity due to the rains and hence these fishes tend to move towards deeper areas of higher salinity.

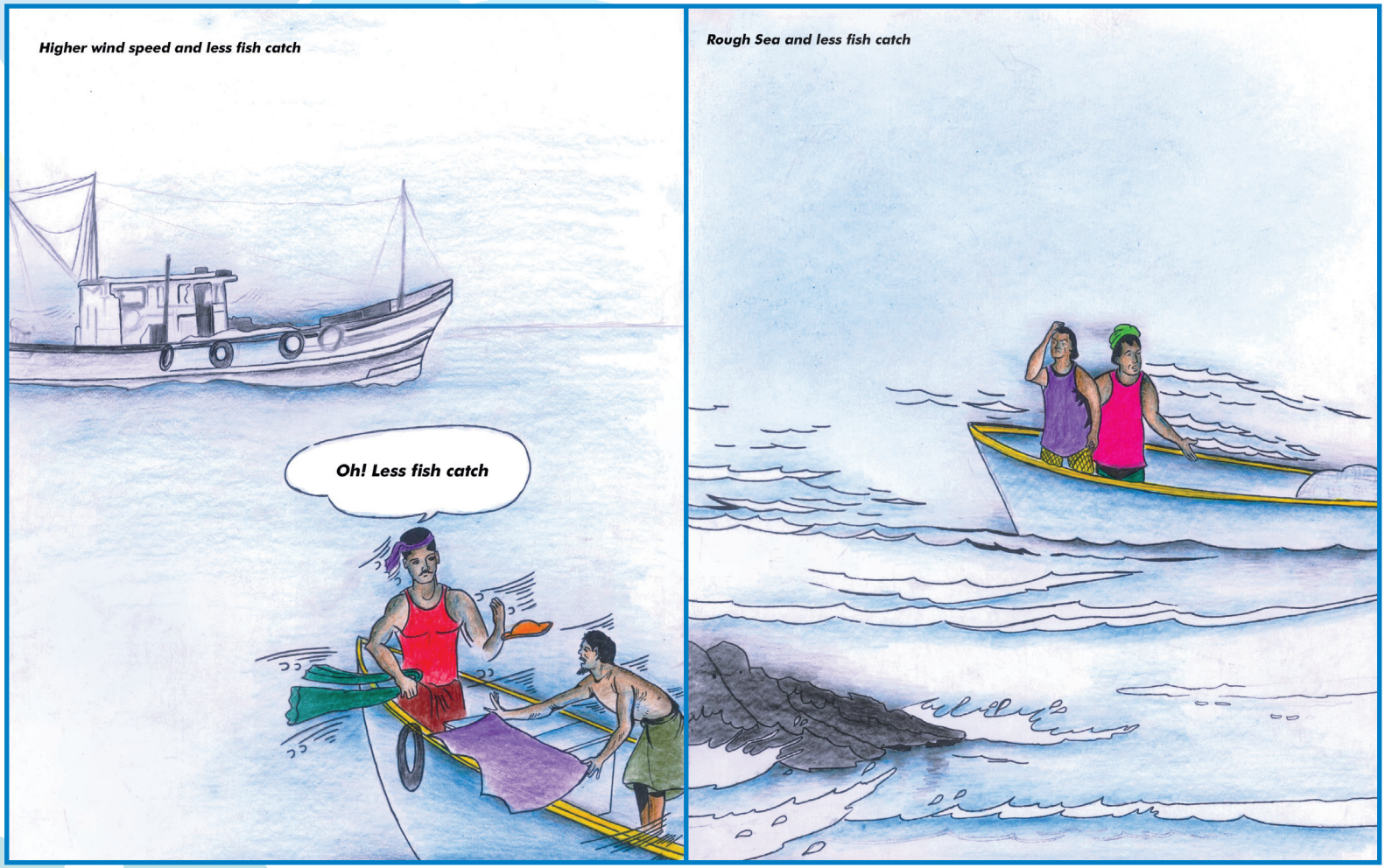


Fig.3 Higher wind speed results in less fish availability, when sea is rough fish catches are less.
Explanation: Rough condition of the sea and high wind speed makes fishing operations difficult and hence results in less fish catch.

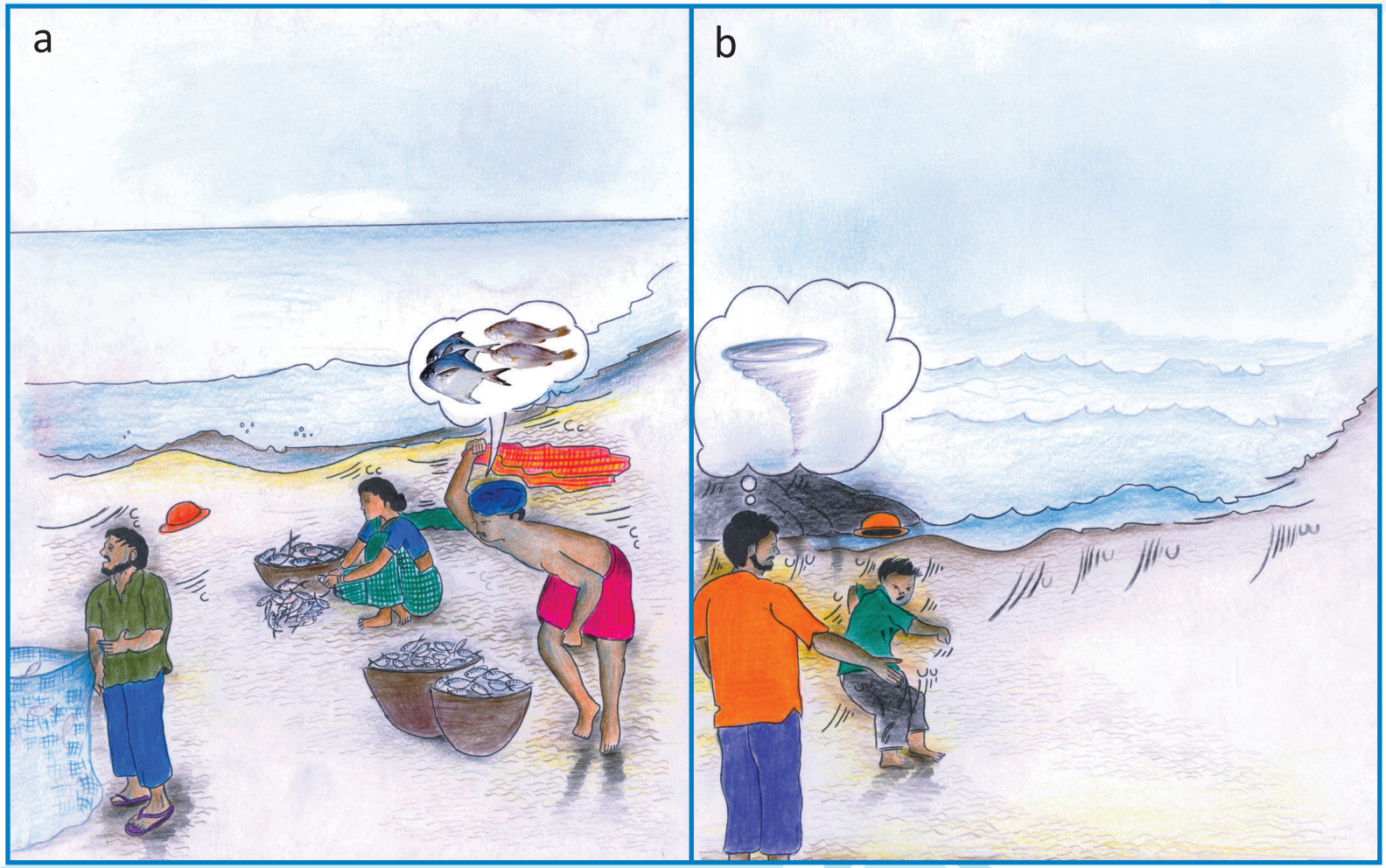


Fig.4 a. When wind blows from west towards shore, fish availability is more.
During summer when shore temperature rises, shore becomes warm and heated air moves up and is replaced by cool wind coming towards shore. The low temperature on the surface water provides the ambient condition for the deep water fishes to come to the surface which leads to good fishery.
Fig.4 b When wind blows from south to north, sea becomes rough and it is an indication of an impending cyclone.

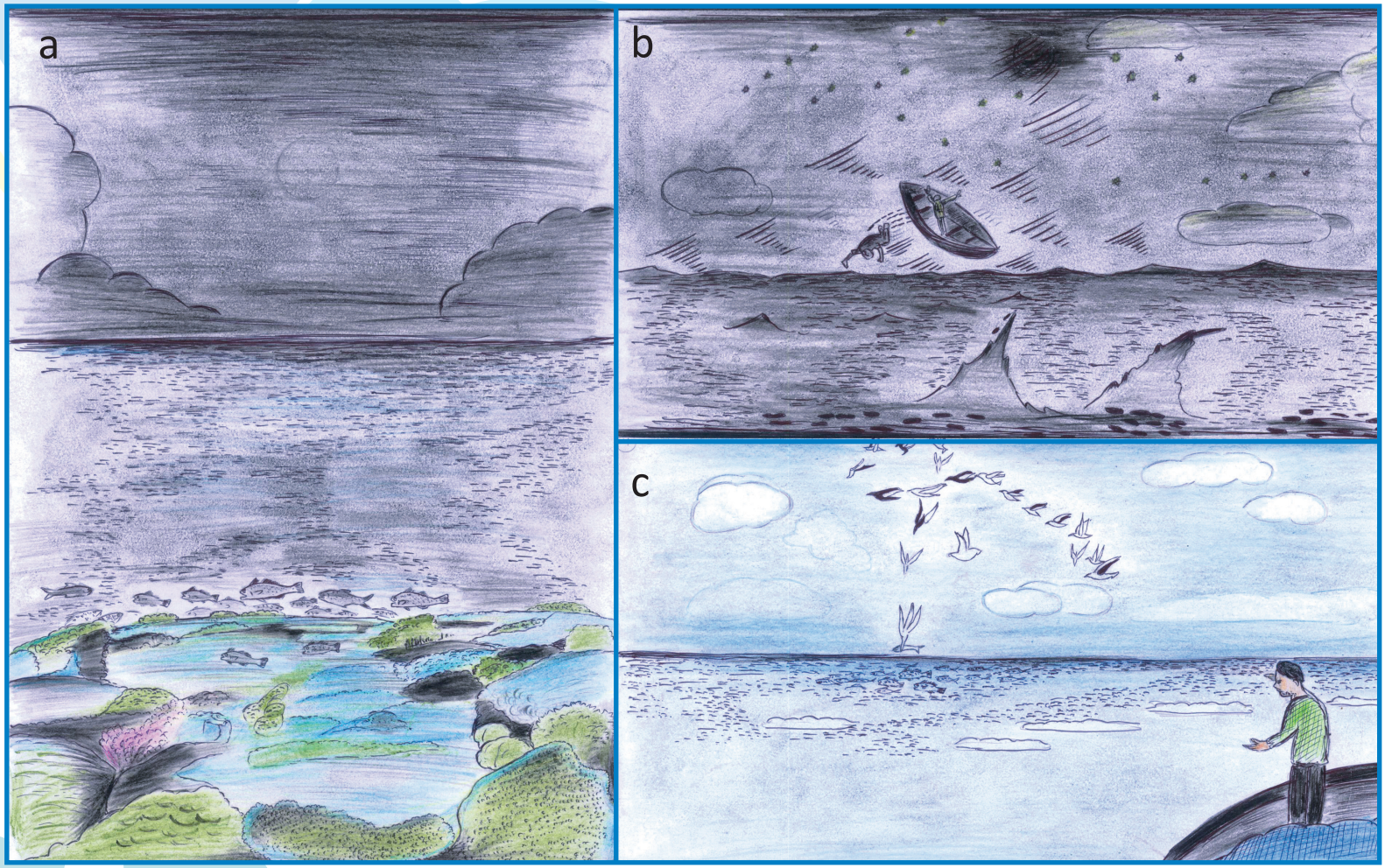


Fig.5a Reef cod fishes are abundant during winter season especially on new moon nights.
Explanation: Reef cod fishes are usually found in deeper waters or crevices avoiding high temperature and light condition. Once surface water become cool, they move towards the surface and abundant catch results.

b. On new moon days stars become faint which is an indication of high wind speed.

c. Gathering of birds over sea surface indicates fish availability in that region
The Seagulls and other sea birds feeds on shoals of fishes and hence more fish availability in that region.

Fig.6 During full moon period more catch of squids are obtained.

Explanation: Fisher folk predict fish availability by observing the conditions of moon and during full moon period, some species of fishes such as the squids are attracted to moon light. There after they come towards sea surface and hence more fish catch results.

Fig.7 More fish availability is obtained with increase in temperature.

Explanation: With increase in temperature, fishes become more active and move towards the upper surfaces of water, whereas with decrease in temperature, the water becomes cold, fishes become non active and move towards bottom contributing to less fish catch.

Fig.8 Fishers predict the arrival of cyclone by observing peculiar circular movements of birds over the sea surface which thereafter moves towards the sky.

6 ITKs' of **Kerala**

The state has 590 km of coastline belt and nine coastal districts namely, Thiruvananthapuram, Kollam, Alappuzha, Ernakulam, Thrissur, Malappuram, Kozhikode, Kannur and Kasaragod. There are 222 marine fishing villages and 187marine fish landing centres in Kerala. There are 1,18,937 marine fishermen households in the state with a population of 6,10,165. Among 1,18,937 fishermen families, 98% are belonged to traditional fishermen. There are 21,781 crafts in the fishery of which 4,722 are mechanized, 11,175 motorized and non-motorized formed the rest.

The following Indigenous Technical Knowledge (ITK) were reported from Kerala.

- If the currents flow from the northern direction, it is an indication of less fish abundance and if the current flow is from the southern direction more fish will be available.
- When the wind blows from the sea side more fish is available and when the wind blows from the land side, less fish is available.
- Very clear water indicates less fish abundance.
- Fish abundance is high when currents are low.
- With rising temperature fishes move to deeper waters.
- If heavy rains are followed by calmer days, than incidence of small pelagic fish catch would be more.

Fig.1 If the current flows from the northern direction, it is an indication of less fish abundance and if the current flow is from the southern direction more fish will be available.

Explanation: In the northern direction when temperature is cool, warm heated air moves up and is replaced by cold wind from the north. Low temperature on the surface waters induces the fishes which lives in deeper waters to come to the surface, which in turn leads to good fishery.

Fig.2 When the wind blows from the sea side more fish is available and when the wind blows from the land side, less fish is available.

Fig.3 Very clear water indicates less fish abundance.
Explanation: Clear water in the sea indicates less phytoplankton productivity, which means less feed for the fishes which in turn leads to poor fishery in these areas.

Fig.4 Fish abundance is high when currents are low.

Explanation: when the currents are low, there is a possibility of few fishes which prefer low current area to congregate in shoals and hence, this increases the chance of good fishery in these areas.

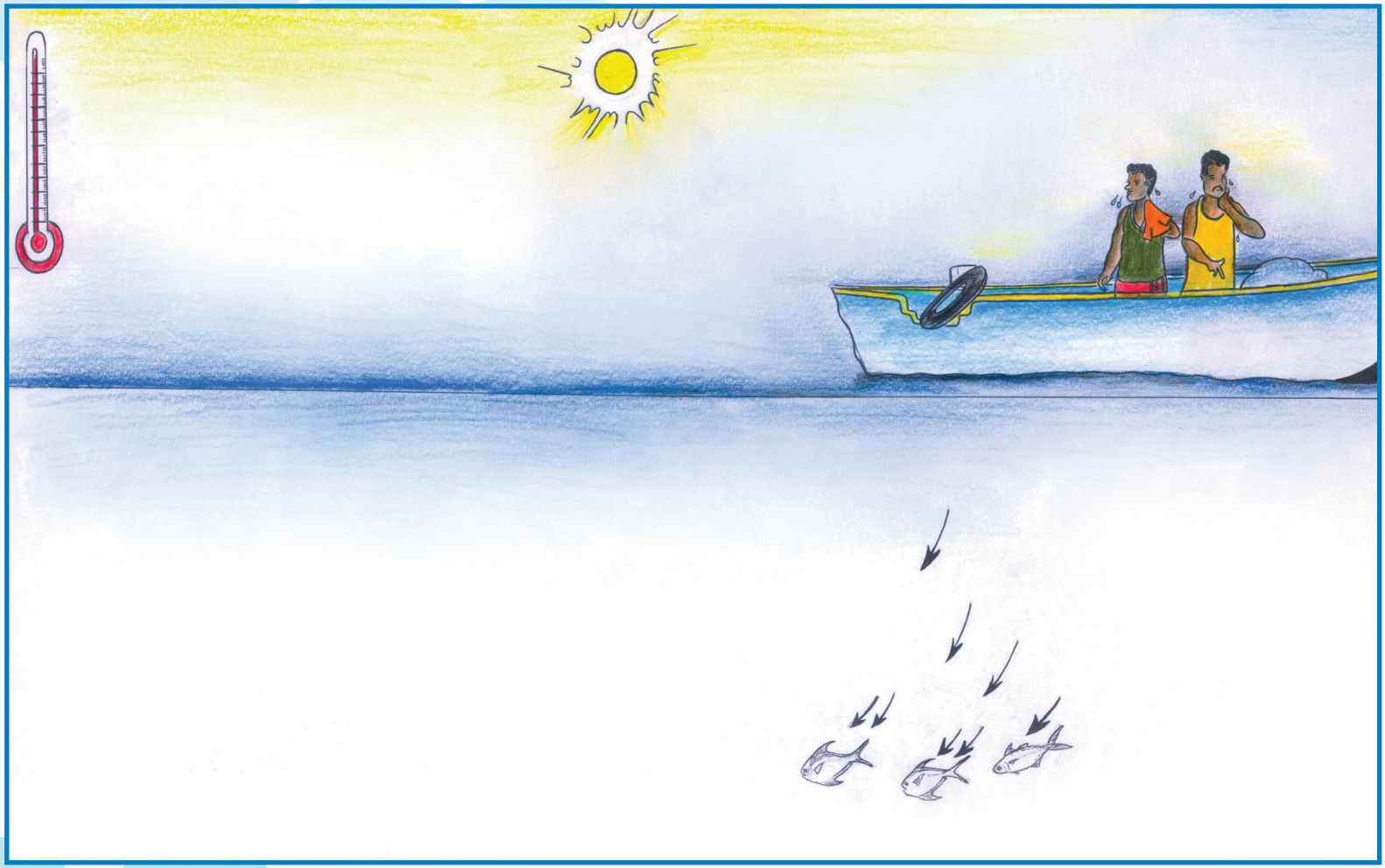


Fig.5 With rising temperature fishes move to deeper waters.

Explanation: Different fishes have different temperature, light and food preferences. Migratory fishes follow the current with ambient temperature which is suitable for them. High temperature on the surface water induces the fishes to move from the surface waters into deeper regions.

Fig.6 If heavy rains are followed by calmer days, than incidence of small pelagic fish catch would be more.

Explanation: During the time of heavy rains the run- off water from the land carries with it a lot of nutrients in to the sea. If rainy days are followed by warmer days, the nutrients in this run off water will enhance the growth of phytoplankton and zooplankton. Once the phytoplankton and zooplankton get established in the waters, it provides feed for small Pelagics, which explains the good catch of these fishes after heavy rains.

7 ITKs' of **Andhra Pradesh**

Andhra Pradesh has the second-longest coastline of 972 km among the maritime States of India. The State comprises of four regions: Telangana, Coastal Andhra, Uttarandhra and Rayalseema. The coastal districts of Andhra Pradesh are, Srikakulam, Vizianagaram, Visakhapatnam, East Godavari, West Godavari, Krishna, Guntur, Prakasam and Sri Potti Sri Ramalu Nellore (called as Nellore in short). There are 555 marine fishing villages and 353 landing centres in Andhra Pradesh. There are 1,63,427 fishermen families in the State with a total population of 6,05,428. Among 1,63,427 fishermen families, 98.5% are traditional fishermen. There are 31,741 crafts in the fishery of which 3,167 are mechanized, 10,737 motorized and non-motorized formed the rest. Majority of the motorized crafts operated in Nellore, Visakhapatnam and Prakasam districts, while non-motorized crafts are more in Visakhapatnam, Srikakulam and East Godavari districts.

The following Indigenous Technical Knowledge (ITK) were reported from Andhra Pradesh.

- Diverse catch of small pelagics, results with incidence of high salinity/decreasing rainfall.
- Wind blowing from north-east direction favours tuna catch.
- Change in water colour coupled with decreasing transparency caused by upwelling results in more catch of small and large pelagics.
- Unidirectional flow of surface currents and wind leads to good pelagic catch.
- Decreasing temperature, moderate sea state and north-east wind favours tuna catch in the months of October – February.
- Increase in catch of crustacean and cephalopod resources are observed with an increase in temperature.
- Inadvertent intrusion of jelly fishes into the coastal waters during summer months results in reduced catch rates of commercially important marine fin fishes and shell fishes.

Fig.1 Diverse catch of small pelagics, results with incidence of high salinity/decreasing rainfall.
Explanation: The pelagic fishes in general prefer high salinity and as the rainfall decreases more diversity of pelagic fish catch occurs.

Fig.2 Wind blowing from north-east direction favours tuna catch.

Explanation: The wind brings with it, changes in oscillation of currents, which in turn brings fishes on which tuna feeds, which results in more tuna catch.

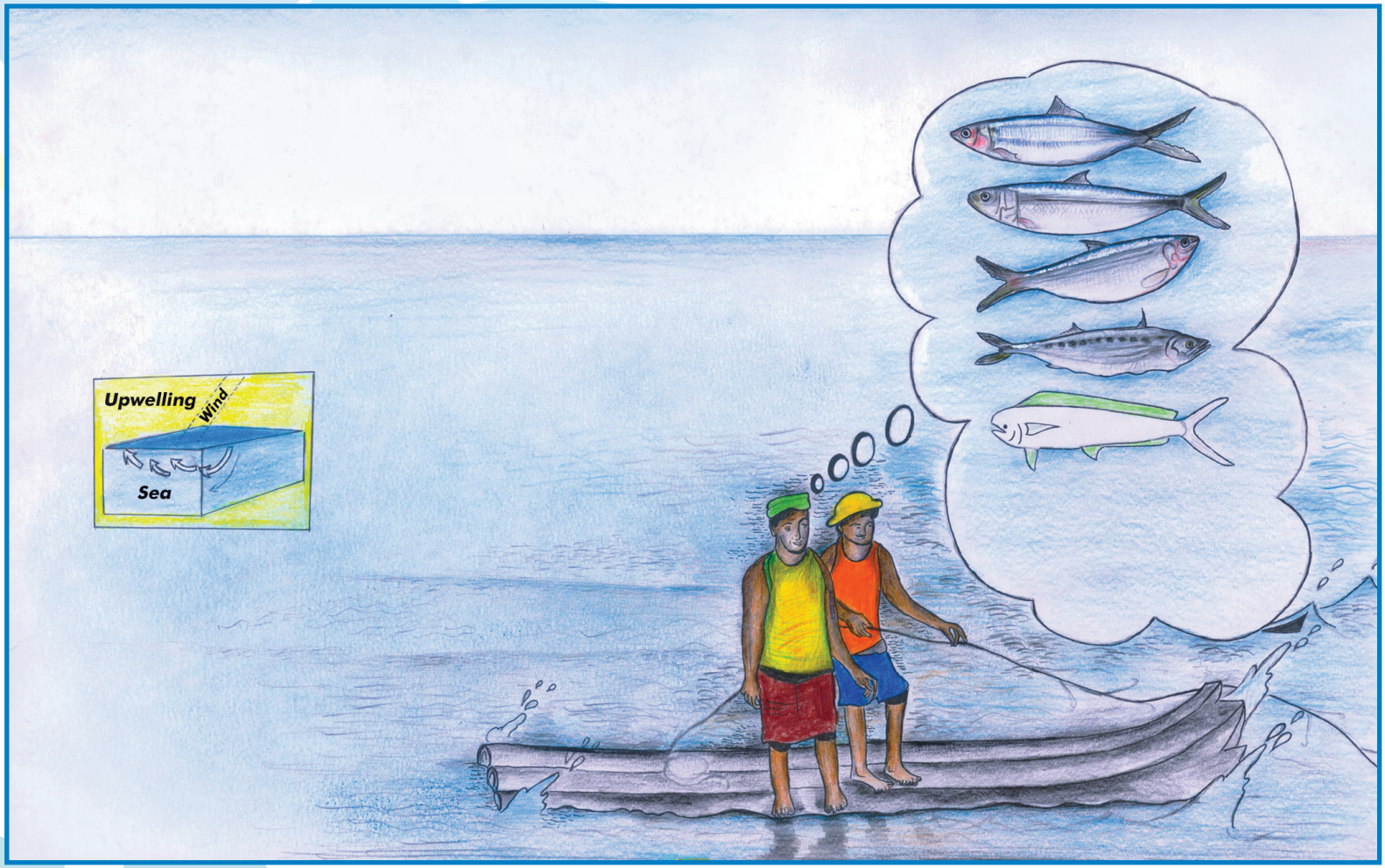


Fig.3 Change in water colour coupled with decreasing transparency caused by upwelling results in more catch of small and large pelagics.
Explanation: The change in water colour could be due to the increase in favourable plankton bloom for pelagic fishes. When the plankton productivity increases, the transparency of the water decreases.

Fig.4 Unidirectional flow of surface currents and wind leads to good pelagic catch.
Explanation: Unidirectional current and wind direction are conducive for the pelagic fishes for feeding which results in aggregation of the fishes, leading to incidence of good fishery in these regions.

Fig.5 Decreasing temperature, moderate sea state and north-east wind favours tuna catch in the months from October – February.
Explanation: Indian ocean dipole (IOD) is an irregular oscillation in which sea surface temperature (SST) becomes alternatively warmer and cooler. Intensity of the IOD is represented by anomalous SST gradient between the western equatorial Indian Ocean (50E-70E and 10S-10N) and the south eastern equatorial Indian Ocean (90E-110E and 10S-0N). This gradient is named as Dipole Mode Index (DMI). When the DMI is positive then, the phenomenon is refereed as the positive IOD and when it is negative, it is refereed as negative IOD. In negative DMI event Decreasing temperature (SST) and increasing net primary productivity occur which results in high catch rate of Tuna. That could be the reason of high catch in October to February.

Fig.6 Increase in catch of crustacean and cephalopod resources are observed with an increase in temperature.
Explanation: Crustacean and cephalopods prefer warm temperature, hence the catch increases with increase in temperature.

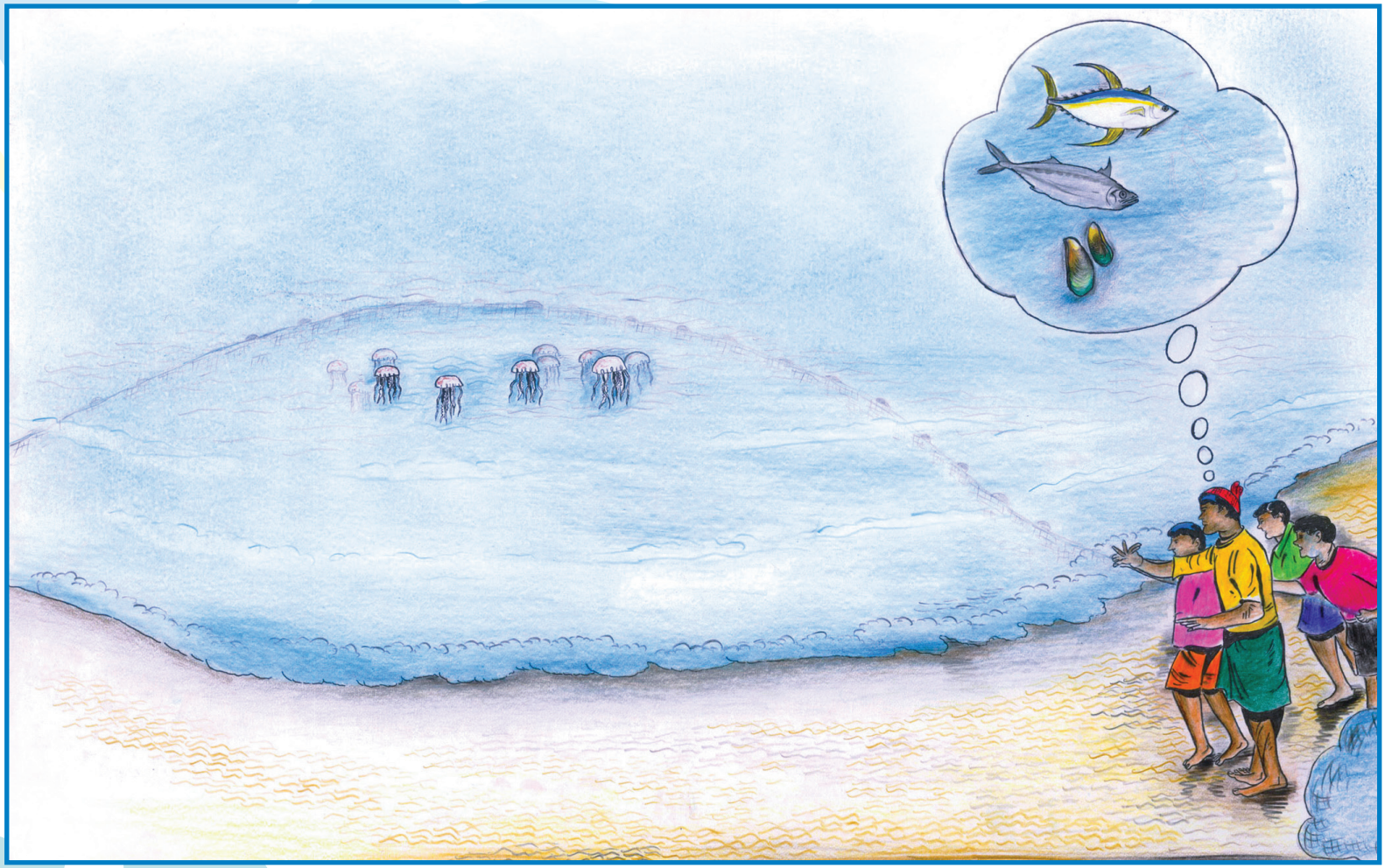


Fig.7 Inadvertent intrusion of jelly fishes into the coastal waters during summer months results in reduced catch rates of commercially important marine fin fishes and shell fishes.

Explanation: Jelly fishes produce some toxins which causes irritations and hence the fishes avoid such grounds.

8 ITKs' of **Tamil Nadu**

Tamil Nadu is the eleventh largest maritime State in India by area and the seventh most populous State. The coastal length of Tamil Nadu is 720 km and comprises of thirteen coastal districts namely, Thiruvallur, Chennai, Kanchipuram, Villupuram, Cuddalore, Nagapattinam, Thiruvarur, Thanjavur, Pudukottai, Ramanathapuram, Tuticorin, Tirunelveli and Kanyakumari. There are 573 marine fishing villages and 407 marine fish landing centres in Tamil Nadu. There are 1,92,697 marine fishermen households in the state with a total population of 8,02,912. Among 1,92,697 fishermen families, 96% are traditional fishermen. There are 46,070 crafts in the fishery of which 10,962 are mechanized, 24,942 motorized and 10,166 are non-motorized.

The following Indigenous Technical Knowledge (ITK) were reported from Tamil Nadu.

- When up and down movement of sea water is more, it indicates less fish availability.
- Increased catch of squids is obtained during the summer months.
- During new moon period (Amavasai) more fish catches are obtained.
- During full moon (Pournami) fish catches are less.
- Bad smell at sea indicates no fish catch.
- When the wind blows from the southern direction during the month of April, fishermen get good fish catch.
- Coastal upwelling brings very good fish catches.
- During the months of October to November, when wind blows from the northern direction, good catches of fish will be obtained.

Fig.1 When up and down movement of sea water is more, it indicates less fish availability.
Explanation: Up and down movement of sea water is an indication of rough seas due to strong wind and water currents. The water becomes turbid and the fishes have a tendency to avoid turbid waters and migrate into shallow areas where the wind action would be relatively less.

Fig.2 Increased catch of squids is obtained during the summer months.
Explanation: When the temperature increases during the summer months it induces enhanced spawning of squids, which results in good catch of squids during summer months.

Fig.3 During new moon period (Amavasai) more fish catches are obtained.

Explanation: During new moon there will be complete darkness and hence the fishes have poor visibility and they get entangled in gillnets and hence good catches of fishes are obtained.

Fig.4 During full moon (Pournami) fish catches are less.
Explanation: During full moon, plenty of light is present and hence fishes have good visibility and tend to avoid fishing nets.

Fig.5 Bad smell at sea indicates no fish catch.

Explanation: The bad smell at sea may be due to the blooming of some algae which causes depletion of oxygen and hence the fishes avoid such areas.

Fig.6 When the wind blows from the southern direction during the month of April, fishermen get good fish catch.

Fig.7 Coastal upwelling brings very good fish catches.

Explanation: During coastal upwelling the nutrient rich waters are brought to the surface which results in increased phytoplankton productivity resulting in good fishery.

Fig.8 During the months of October to November, when wind blows from the northern direction, good catches of fish will be obtained.
Explanation: During October- November (winter season) the wind blowing from the northern direction brings in cool air, which brings with it good fish catches.

9 ITKs' of **West Bengal**

West Bengal has the fourth-longest coastline of 950 km among the maritime States of India. The coastal districts of West Bengal are Purba Medinipur, South 24 Paraganas, Howrah and North 24 Paraganas. There are 188 marine fishing Grama Panchayats (GP) and 59 landing centres in West Bengal. There are 76,981 fishermen households in the State with a total population of 3,80,138. Among 76,981 fishermen families, 53,532 (70%) are traditional fishermen families. There are 17,348 crafts in the fishery of which 14,282 are mechanized, 3,066 non-motorized.

The following Indigenous Technical Knowledge (ITK) were reported from West Bengal.

- Increase in catch of clupeids and mackerel is observed with an increase in temperature.

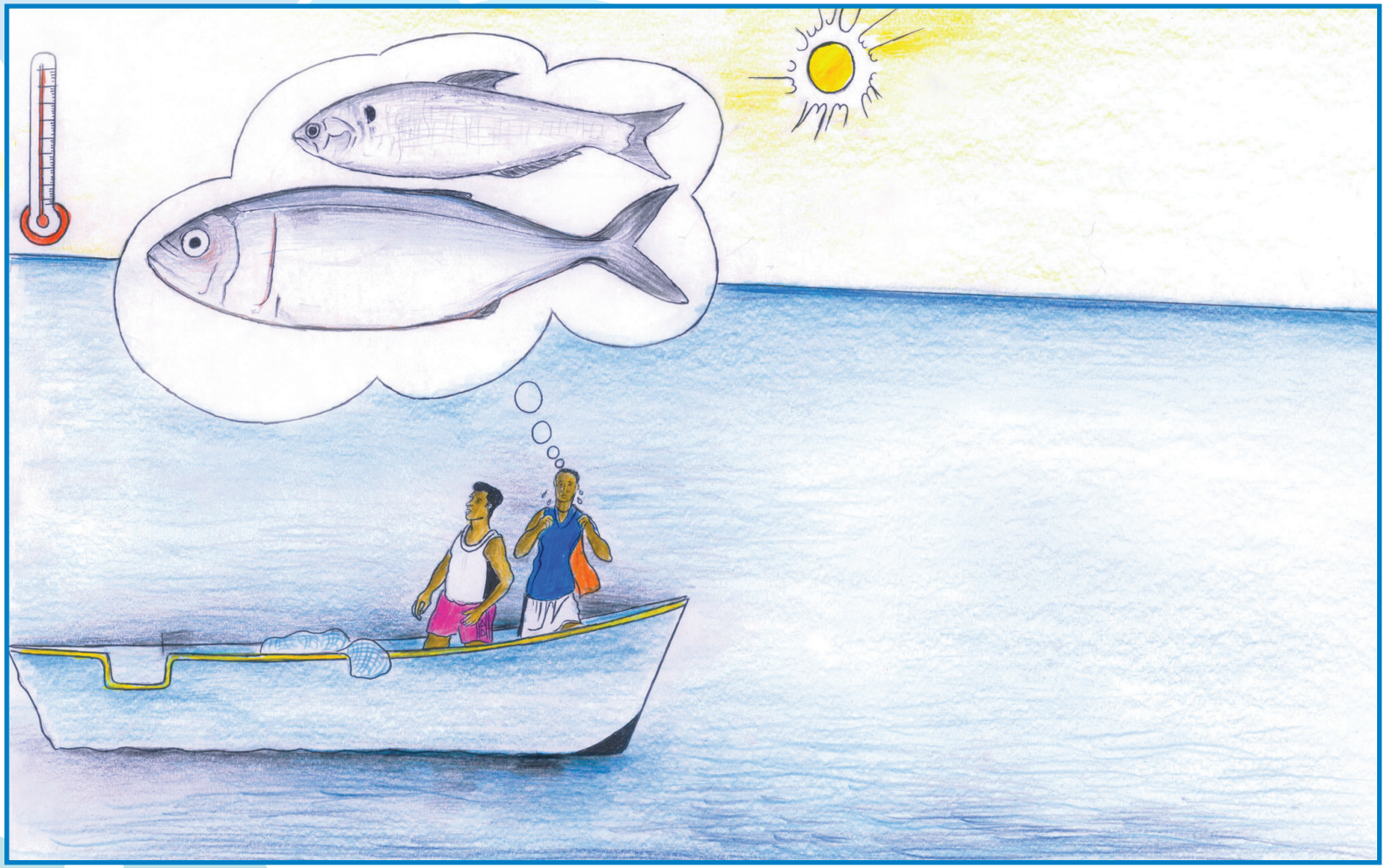


Fig.1 Increase in catch of clupeids and mackerel is observed with an increase in temperature.
Explanation: With an increase in temperature over the last few decades in the northern part of India, sardines are found to appear in the fishery of this State. The extended distribution of sardines during the last decade, in to West Bengal waters is taken as a visible impact of climate change in the Indian waters.

10 ITKs' of **Odisha**

The coastal length of Odisha is 560 km and consists of six coastal districts namely, Balsore, Bhadrak, Kendrapara, Jagatsinghpur, Puri and Ganjam. There are 813 marine fishing villages and 73 marine fish landing centres in Odisha. There are 1,14,238 marine fishermen families in the State with a population of 6,05,514. Among 1,14,238 fishermen families, 77% are traditional fishermen. There were 10,826 crafts in the fishery of which 2,248 are mechanized, 3,922 motorized and the rest non-motorized.

The following Indigenous Technical Knowledge (ITK) were reported from Odisha.

- Increase in catch of clupeids and mackerel is observed with an increase in temperature

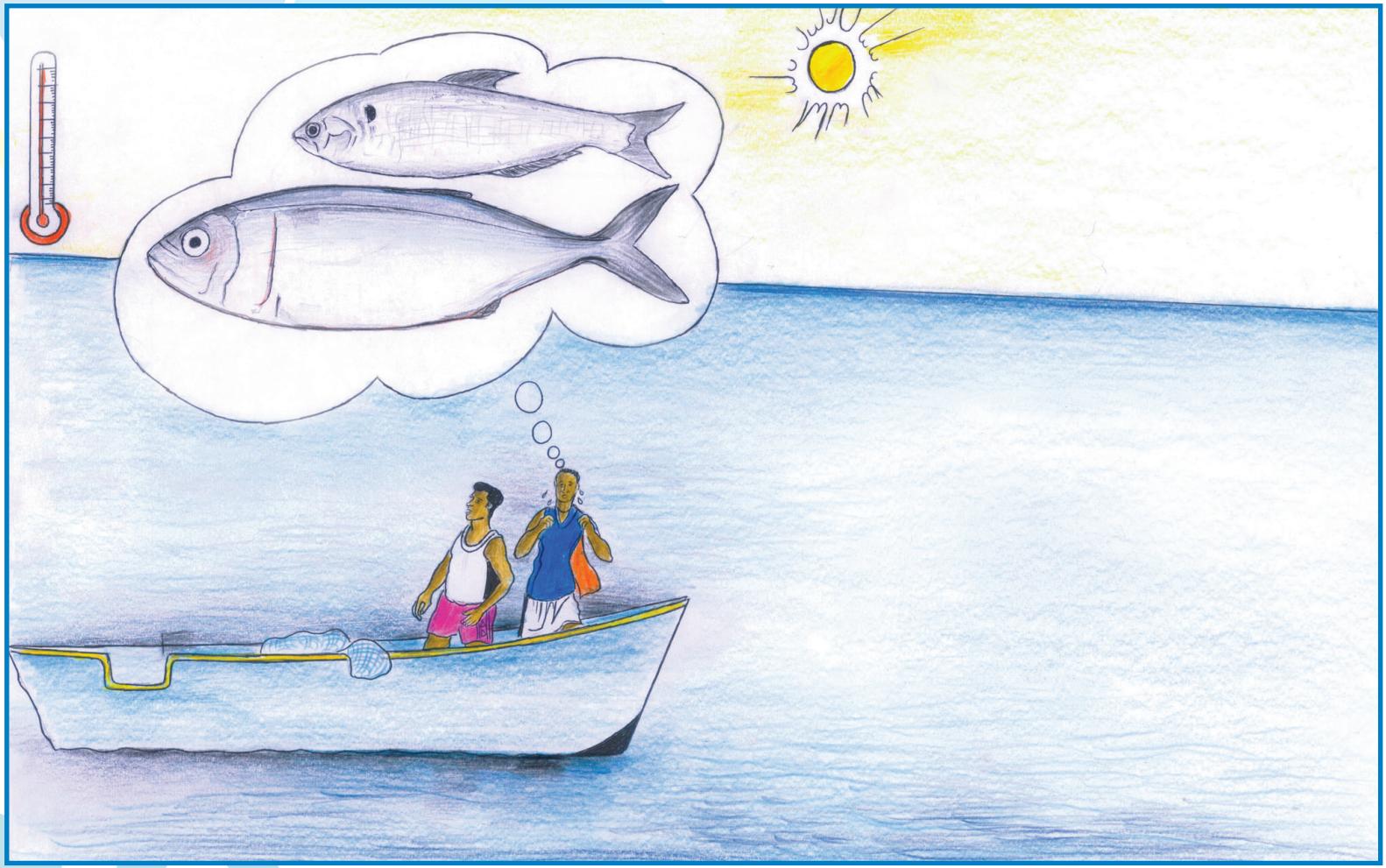


Fig.1 Increase in catch of clupeids and mackerel is observed with an increase in temperature.

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We are deeply indebted to the millions of fisherfolk in the Indian marine fisheries scenario, who have been the custodians of traditional knowledge in marine fisheries with respect to climate change, for their tireless efforts and whole hearted dedication in sharing their valuable knowledge base with the researchers.

The fishermens' knowledge merits due veneration, in the context of the ITKs' being able to play complimentary role to scientific resource management.

The book transcends on an era of antiquity, when predictions on climate related parameters were made based on wind directions, water currents, orientation of constellations and behaviour of insects and birds. Salutations are due to the guardians of this ancient knowledge system.

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Annexure

Interview schedule: ITK of fisherfolk on climate change

Survey No:-

District name: _____ Village name: _____ Ward No : _____

1. Name and address of the respondent with phone number:- _____

   Age of the respondent: _____ and years of experience in fishing: _____

2. Do you know that climate is changing? Yes/No

3. If yes, give rank on which parameter is changing and which is more important to fisheries?

Sl.No.	Parameters	Rank based on change.	Rank based on importance to fishery.
1	Temperature		
2	Salinity		
3	Sea level rise		
4	Coastal upwelling		
5	Wind direction/speed		
6	Rainfall		
7	Chlorophyll		
8	Others(specify)		

4. Do you face more problems in the last 20 years due to

   a) Erosion

   b) Cyclone

c) Sea status

d) Ground water salination

e) Others (specify)

5. In your opinion, what are the major problems facing fisheries?

Sl.No.	Problems facing fisheries	Rank
1	Overfishing	
2	Juvenile Exploitation	
3	Habitat destruction	
4	Climate change	
5	Others(specify)	

6. With relevant to weather related problems, what are the adaptation options you suggest?

a) Safe exit

b) Coastal protection structures

c) Common shelters

d) Rehabilitation

e) Others

7. Among fishermen, who are more vulnerable to weather related problems?

Sl.No.	Vulnerable sections	Rank	Vulnerable sections	Rank
1	Fisherman		Mechanised sector	
2	Fisherwomen		Motorised sector	
3	Children		Traditional Sector	
4	All		Traders	
5			All	

8. Are you prepared to take weather-related insurance without external support? Yes/No

9. Do you regularly read or watch newspapers, radio, T.V, any other bulletins? if yes, which is more relevant in your life?

If yes, do you take any precautions? Yes / No.

10. Is there increase/change in disease occurrence among fishermen in the last 20 years? Yes/No if yes, give details.
11. Is there change in the type and quantity of fish availability in recent years? Yes/No.

    If yes, what is the change?
12. Can you predict weather from climatic/oceanographic conditions? Yes/No.

    If yes, how?
13. Can you predict fish catch from climatic/oceanographic conditions? Yes/No.

    if yes, how?
14. Other awareness.

Name and address of the enumerator

Date:.../..../.....

Place:

National Initiative on Climate Resilient Agriculture

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